

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

(NASA-CR-176333) R AND D LIMITED
PARTNERSHIPS (POSSIBLE APPLICATIONS IN
ADVANCED COMMUNICATIONS SATELLITE TECHNOLOGY
EXPERIMENT PROGRAM) (ECON, Inc.) 75 p
HC A04/MF A01

N86-13221

Unclass

CSC 05A G3/81 16226

NASW-3339
R&D LIMITED PARTNERSHIPS
(POSSIBLE APPLICATIONS IN ADVANCED
COMMUNICATIONS SATELLITE TECHNOLOGY
EXPERIMENT PROGRAM)



80-111

NINE HUNDRED STATE ROAD
PRINCETON, NEW JERSEY 08540
TELEPHONE 609 924 8778
TELEX 642 215

✓
**R&D LIMITED PARTNERSHIPS
(POSSIBLE APPLICATIONS IN ADVANCED COMMUNICATIONS
SATELLITE TECHNOLOGY EXPERIMENT PROGRAM)**

submitted to

**National Aeronautics and Space Administration
Washington, D.C. 20546**

Under

Contract No. NASW-3339

Prepared by

**ECON, Inc.
900 State Road
Princeton, NJ 08540**

June 22, 1984

Disclaimer

The objective of this study is to provide insight into the role that R&D Limited Partnerships may play in encouraging private sector use of the NASA developed advanced satellite communications technologies. The formation of R&D limited partnerships is a complicated endeavor and requires expert counseling, intensive research, and serious evaluation of the available alternatives and possible structures. This report should not be used to substitute for any of that counseling, research and evaluation.

ABSTRACT

In order to help stimulate investment in high technology R&D, the Administration has promoted the R&D Limited Partnership (RDLP). The RDLP concept enables the funding and conduct of R&D efforts in a manner that can be distinctly advantageous relative to other organizational forms and can thus have an impact on the private sector markets for NASA technology. The RDLP can provide substantial tax advantages to investors, dramatically improving the rate of return on certain R&D activities, and it can enable collaboration between otherwise competing organizations which, outside the framework of the RDLP, would be judged to be in violation of antitrust legislation. The RDLP allows for a basic separation between R&D and operations with each providing an expected return to offset the associated risk.

This report describes typical R&D limited partnership arrangements, advantages and disadvantages of RDLPs, and antitrust and tax implications. A number of typical forms of RDLPs are then described that may be applicable for use in stimulating R&D and experimental programs using the Advanced Communications Technology Satellite—the ultimate goal being to increase the rate of market penetration of goods and/or services based upon advanced satellite communications technology. The conditions necessary for these RDLP forms to be advantageous are described.

ACKNOWLEDGEMENTS

This study was performed by Ms. Carole Gaelick and the undersigned, both of whom also authored this report.

The authors are indebted to Dr. Joe Clarke, John Jerke, and other Department of Commerce staff for their helpful support during the course of this study.

The NASA technical officer for this study was Dan Brandel.

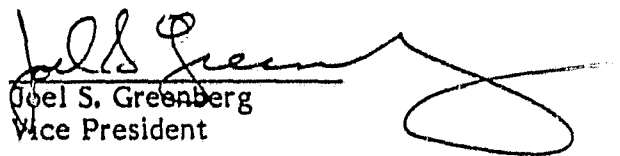

Joel S. Greenberg
Vice President

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
Abstract	ii
Acknowledgements	iii
List of Figures	v
List of Tables	vi
1. Introduction	1
2. R&D Limited Partnerships	5
2.1 Background and Purpose of RDLPs	5
2.2 RDLP Arrangements	8
2.3 Advantages of RDLPs	19
2.4 Disadvantages of RDLPs	27
2.5 Antitrust Implications	29
2.6 Tax Implications	31
2.7 Formulation of the RDLP Business Plan	33
3. Advanced Communication Satellite Technology Program	37
3.1 Introduction	37
3.2 Review of ACTS Program	38
3.3 Proposed Experiments	46
4. RDLPs Applied to ACTS Experiments	51
5. Summary/Conclusion	63
References	67

LIST OF FIGURES

<u>Section</u>	<u>Page</u>
2.1 Illustration of Single Company RDLP (The Sponsoring Organization Concept)	11
2.2 Limited Partnership for Trilogy Technology (The Sponsoring Organization Concept) (From Ref. 1)	12
2.3 Limited Partnership for BEHR Technology (The Multi-Project General Partnership) (From Ref. 1)	13
2.4 The Independent Entrepreneur General Partnership	14
2.5 Normalized Value of RDLP Financing Compared to Debt Financing in Terms of Likelihood of R&D Project Success	25
3.1 ACTS Program Schedule	38
3.2 Schematic of Advanced Communications Technology Satellite System (From Reference 10)	39
4.1 Typical Structure for Sponsoring Organization Form of RDLP	53
4.2 Typical Structure for RDLP Leading to New Venture (Sponsoring Organization Arrangement)	56
4.3 Typical Structure for RDLP Leading to New Venture (Entrepreneur Arrangement)	59
4.4 Typical Structure for RDLP Leading to Limited Partners Pursuit of Business Activities	62

LIST OF TABLES

<u>Section</u>	<u>Page</u>
2.1 Simplified Comparison of Alternate Financing Schedules (R&D Phase Only)	21
2.2 Simplified Comparison of Debt and RDLP Financing	22
3.1 Notice of Intent Responses	47-49

1. INTRODUCTION

A stated policy of the Reagan Administration is to involve the private sector to an increasing extent in the funding and management of research and development (R&D) projects. To this end, the Administration has promoted an environment within which certain high technology R&D projects might be conducted profitably.* The environment is referred to as the R&D Limited Partnership (RDLP).** The RDLP concept enables the funding and conduct of R&D efforts in a manner that can be distinctly advantageous relative to other potential formats and can thus have an impact on the private sector markets for NASA technology. Principally, the RDLP can provide substantial tax advantages, dramatically improving the rate of return on certain R&D activities, and it can enable collaboration between otherwise competing organizations which, outside the framework of the RDLP, would be judged to be in violation of anti-trust legislation. The RDLP allows for a basic separation between R&D and operations with each providing an expected return to offset the associated risk.

The RDLP is a type of business organization which makes it possible for companies to have another option for financing research and development. Instead of using debt provided by lenders, equity provided by stockholders, or cash provided by internal operations, a company can look to investors seeking an attractive tax shelter opportunity. An RDLP may be used to finance an existing firm's R&D, or can provide the R&D seed money for a start-up business. It offers an effective means of financing small and large scale projects.

*The Department of Commerce has sponsored a conference on the Formation of R&D Limited Partnerships in several U.S. cities this year. Individuals in DOC's Office of Productivity, Technology, Innovation are accessible and responsive to queries on RDLPs. The Department has published guidelines to forming RDLPs (Reference 1). A number of bills have been sponsored in Congress that are favorable to joint venture R&D.

**Examples of RDLPs are discussed in Section 2.2.

The classic R&D partnership structure is technically straightforward. A limited partnership is formed with either an individual or a corporation as general partner; the general partner provides management and the limited partners the capital. Frequently there is a sponsoring company that provides a technology base for the partnership and performs the research for the partnership under contract. As funds are provided the limited partners may achieve tax write-offs. Upon successful completion of the R&D the sponsoring corporation may exercise an option to acquire the developed technology and market related products in return for the partnership receiving royalty or other payments. These payments may receive capital gains treatment by the partners.

It is through the combination of high rates of return (resulting from the favorable tax treatment for the limited partners) and risk reduction (resulting from the pooling of assets) that R&D investment decisions will be effected and investments stimulated. The R&D partnership is designed to efficiently use available tax benefits to minimize the investor's after-tax capital at risk and augment the after-tax payout. And if the project proves successful, the royalties paid to the partnership may be taxable at long-term capital gain rates.

The National Aeronautics and Space Administration (NASA) is conducting an Advanced Communications Technology Satellite (ACTS) Program to advance the high risk technology required to ensure continued United States' preeminence in the field of satellite communications. The objectives of the ACTS Program are to develop and validate the technology required to enable growth in the capacity and effective utilization of the frequency spectrum and to effect new and innovative uses for satellite communications. NASA had originally proposed to begin the flight experimentation phase of the program, and had initiated the procurement process for the ACTS flight system and supporting ground terminal equipment.

Subsequently, NASA revised the program to include only ground testing of the system technology. Congress is currently evaluating the need for a flight test program. If approved by Congress for a start in fiscal year 1985, the ACTS spacecraft was scheduled for launch into geostationary orbit by the Space Transportation System (Space Shuttle) in 1988.

The ACTS communications technology program will incorporate the high risk technologies necessary to permit more efficient use of orbit and spectrum resources and to allow for new forms of communication data transfer. Operation will be in the 30/20 GHz frequency band. A nominal two-year period for experiments has been planned. The technology developed under the ACTS Program will be usable in multiple frequency bands and will be applicable to a wide range of future communication systems required by NASA, other government agencies and U.S. Industry.

In order to assess the applicability of RDLPs it has been assumed that a space test program would be initiated and that an R&D and experimental program would be encouraged. It is with respect to this R&D and experimental program that RDLPs are herein considered.

In keeping with the foregoing assumption it is assumed that a primary goal of the ACTS Program is to make available to the public and private sector (corporations, universities and government agencies) the capabilities of an ACTS spacecraft for experimentation. It is assumed that it is the intent of NASA to consider all experiments technically and scientifically relevant to the basic objectives of the ACTS Program and for which the ACTS System can accommodate. It is assumed that NASA will develop a flight system and provide access to the ACTS space segment at no cost to the experimenter. Each experimenter will be responsible for the conduct and funding of their experiment, including ground terminal equipment and operations.

A number of experiments have been proposed and general interest has been indicated for performing others. The purpose of this study was to provide insight into the role that R&D limited partnerships may play in encouraging private sector experimentation with an ACTS spacecraft with the ultimate objective of encouraging private sector use of the NASA developed technologies and thus increasing the rate of market development. In the following pages the concept of R&D limited partnership is described as are the advantages, limitations, anti-trust implications, tax implications and the formulation of the RDLP business plan. Typical ACTS requirements are described and the applicability of and the form or structure of RDLPs are described. Conclusions are then presented regarding the likely impacts or importance of RDLPs in fostering experimentation with the ACTS spacecraft.

2. R&D LIMITED PARTNERSHIPS

2.1 Background and Purpose of RDLPs

R&D limited partnerships (RDLP's) provide a means of raising funds for high risk, high technology research and development projects. This provides an alternative to the traditional sources of financing for business research and development, removing the limitations on R&D that might occur if the R&D is financed out of a firm's retained earnings or by borrowing money [1]. If structured correctly, the RDLP can avoid major antitrust problems [2].

RDLP's may be used by single companies to finance their own R&D or by groups of companies to accumulate R&D funds for high risk, expensive projects in an environment that may avoid antitrust suits. RDLP's may provide seed money for start up businesses [3]. RDLP financing supplements conventional capital financing such as debt and equity. The partnership may be offered at any dollar amount, may be syndicated in a public or private offering, and the sales may be limited locally or nationally. Most of the current activity is in small, private placements [4].

Capital raised may range from \$500,000 to over \$50 million. Required minimum investments may be as high as \$150,000. Some publicly registered limited partnerships have raised funds ranging from \$20-\$100 million. Offerings in publicly registered partnerships have required investments as low as \$5,000 per partner [5]. One private source estimates that RDLPs formed in 1983 raised capital on the order of \$800 million [4].

Essentially, the RDLP raises money from a group of investors, referred to as limited partners, who have no say in the management of the funds. These investors may be at substantial risk, but they can deduct a sizeable portion of the investment

against their ordinary income if the partnership meets certain criteria, thereby reducing the after-tax dollars that they have at risk.

The partnership is managed by a General Partner who is required to invest a small percentage of the whole. Frequently, a company sponsors the RDLP and it, or a subsidiary or other affiliate may serve as the General Partner or a non-related group may be the General Partner. Funds raised by the partnership are used to finance R&D projects, which, depending on the partnership arrangement, may or may not be specified in advance by the General Partner. Frequently the sponsoring company undertakes the R&D under contract to the partnership and obtains the right, through an option and appropriate payments, to acquire the developed technology and to produce, market and sell related products.

There is no guarantee of return to the investors and if the endeavor is a complete failure the partners sustain the loss. No other company is liable to the partnership in this case. If the research and development results in commercially successful products, however, the returns to the partners can be high. The limited partnership owns the rights to technology developed as a result of the R&D, but usually the sponsoring company has the option to purchase the technology or obtain an exclusive license to produce and market products using the technology. The company makes a lump sum payment or pays royalties to the partnership based on sales in return for technology rights. These royalties or lump sum may be taxed at long term capital gains rates (up to 20%) rather than as ordinary income (up to 50%). Income from royalties or lump sum payment is independent of the long-term profitability of the corporation that obtains the technology. The advantage is that partners receive payments as soon as sales begin with the income spread over several years (in the case of royalties).

Alternative arrangements through which the sponsoring company acquires rights to the technology include equity partnerships and joint ventures. Equity partnerships usually provide seed capital or first-round financing for new ventures. The partnership and company agree to form a new corporation after the technology is developed, which will manufacture and market the new product. The partnership has the option to convert its interests to equity in the new corporation in a tax free transaction [1,6,7].

In a joint venture, the company and partnership form an entity to manufacture and market the product after the technology has been developed. At some point, one of the parties buys out the other's interest in the venture. This joint venture arrangement, from the company's perspective may be viewed as an interim step allowing the company to start production and marketing. During this time the profits are split between the company and the partnership. Profits are usually less than royalty payments so the company has more money to work with than under the royalty arrangement. Once production and marketing has begun the company may buy out the partnership interest by paying royalties or a lump-sum [6].

A number of bills are before Congress that are favorable to joint venture R&D efforts. The proposed legislation would protect companies performing collaborative R&D from private and government anti-trust suits, reduce suits against joint ventures from treble to single damages, modify patent and copyright law to encourage joint ventures, confirm favorable tax treatment and allow a 25% investment tax credit for expenditures on R&D. Several of those bills are still in committee and no action has been taken on them in several months. One of the much more moderate bills has been ordered reported out of the House Judiciary Committee (H.R. 5041) and recent hearings have been held on its counterpart in the Senate Judiciary Committee (S. 1841). This version limits damage suits to

actual rather than treble damages, and the Senate bill, in addition, extends protection of patent and copyright holders. Another bill that is in the Senate Finance Committee and on which recent hearings have been held would amend the Internal Revenue Code to encourage increased research activities. The bill would make the 25% R&D credit permanent (previously it was applicable until 1985). It would also modify the definition of qualified research for credit purposes, targeting the credit to technological innovations developed through a process of experimentation relating to new or improved functions, performance, etc. The bill would also consider R&D expenditures incurred by a partnership "in carrying on a trade or business of the partnership as determined at the partnership level without regard to the trade or business of any partner" as eligible for the credit.

2.2 RDLF Arrangements

An RDLF partnership consists of two types of partners: general partners and limited partners. The general partner or partners manage the partnership, obtain funding, arrange for the research to be performed, and ultimately either manufacture any new products resulting from the R&D, or license out the resulting technology. The limited partners invest in the partnership, bear most or all of the financial risk, share in the financial success from the proceeds of manufacture, royalties or other paybacks, and receive tax benefits, but play no active management role in the partnership.

Other participants common to most RDLFs are:

- The R&D contractor(s) performing the research work, under contract to the partnership;
- The investment broker who helps raise the capital;
- The manufacturer/marketer who makes and sells the products that result from a successful research effort, if the partnership decides to license the research results;

- The prospective user of the technology to be developed [1].

Various relationships among these different participants are possible.

The organization conducting the R&D under contract to the partnership may be one of the partners or may be independent of the partnership. Similarly, the partnership may wish to manufacture and sell the resulting products, or the manufacturer may be an independent company. The partnership must obtain access to the basic technology required to carry out the research and does this via a cross license and transfer agreement with the company owning the technology. Once the research is complete the partnership owns the resulting technology and typically has an agreement with a prospective manufacturer which may be a subsidiary of the General Partner, giving the manufacturer the option to acquire the technology rights. The manufacturer is under no obligation to purchase the technology rights. This stipulation is necessary for the investment to be considered "at risk" and the investors therefore to be entitled to the Section 174 of the Internal Revenue Code deduction [1,3,6,7]. The important point is that in order to raise the funds necessary from the investors it is necessary that the partnership have clear title to the technology base and the patents and/or product that are likely to result from the R&D activity.

If the prospective manufacturer exercises its option to purchase the technology rights, it usually pays the partnership royalties based on gross sales of products that make use of the technology.* Royalty rates often range from 2%-10% of gross sales [3]. The rate may remain constant or decline as sales grow. Usually there is an upper limit (or cap) on total royalties paid or on the time period in which royalties must be paid to the partnership. Sometimes there is a minimum or maximum limit on annual royalties [3,6]. Minimum royalties should be used

* In order to avoid future problems it is important to clearly define in advance what constitutes use of the technology (patents).

with caution, as they might be perceived by the IRS as reducing the partnership's risk to the point where qualifications as an RDLP may be jeopardized.

The manufacturer may have an option to pay the partnership a lump sum rather than royalties. Or the partnership may receive stock in the company rather than cash, or in addition to royalties [6].

In the following pages several typical RDLP organizational/financial arrangements are described. These include (1) an organization established based upon a sponsoring company (i.e., the company wishes to pursue an R&D program and initiates the formation of the RDLP) performing research under contract to the RDLP, (2) an organization established to conduct research for several unrelated companies (multi-project general partnership), and (3) an organization established by an entrepreneur independent of any existing company (the independent entrepreneur general partner).

In the first case an existing company decides to sponsor an R&D limited partnership to finance R&D that may lead to the development of a technology upon which one or a number of new or improved products may be based. The partnership enters into an R&D agreement with the corporation under which the partnership pays (contracts with) the company to develop the new technology. This is illustrated conceptually in Figure 2.1 and for an actual case in Figure 2.2. Referring to Figure 2.1, the investors provide funds to the RDLP which enters into a contract with the sponsoring organization to perform the desired R&D. The sponsoring organization provides the R&D base and signs over patents resulting from the R&D to the partnership. An option is usually provided whereby the sponsoring organization can acquire the patent rights and can then proceed to manufacture and sell products based upon the developed technology. In order to exercise the option a lump sum payment (cash or stock) can be made or royalty

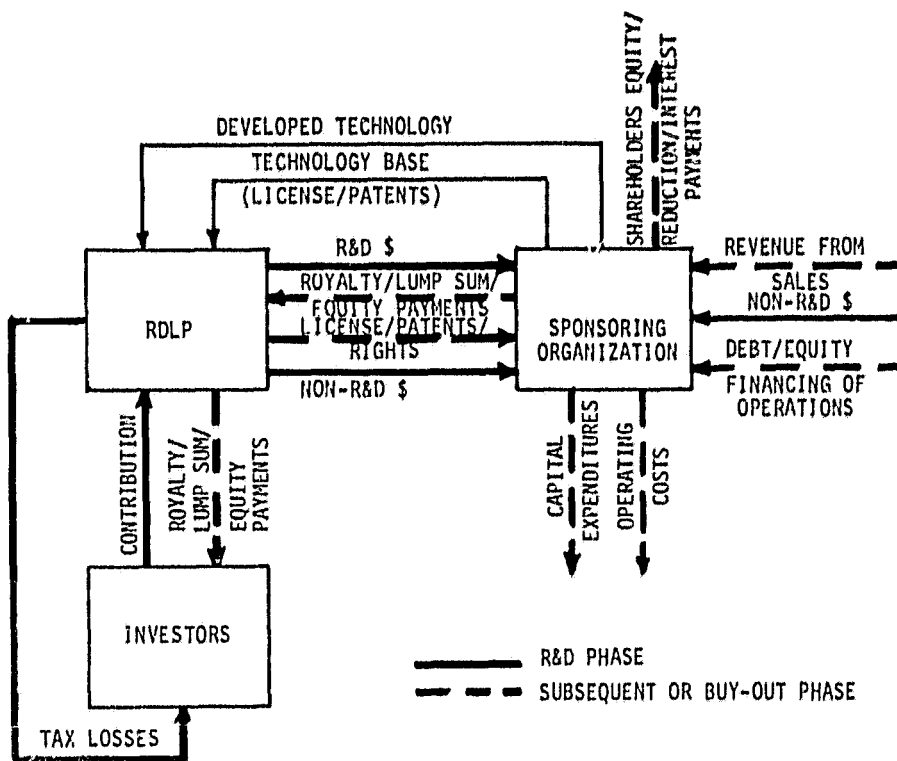


FIGURE 2.1 ILLUSTRATION OF SINGLE COMPANY RDLP
(THE SPONSORING ORGANIZATION CONCEPT)

payments made based upon future sales. The option agreement is part of the RDLP formation agreements. There are several advantages to a company in financing a research and development project through an RDLP rather than by selling stock or borrowing, and these are discussed in section 2.3.

In the second case (Figure 2.3), several companies fund their projects through a single partnership. One company serves as General Partner and conducts research for more than one company. The RDLP is independent of any of the companies doing the research [1].

In the third case (Figure 2.4), the General Partner is an independent entrepreneur whose RDLP is a subsidiary of no other business. The General Partner must seek out organizations possessing technology the partnership will

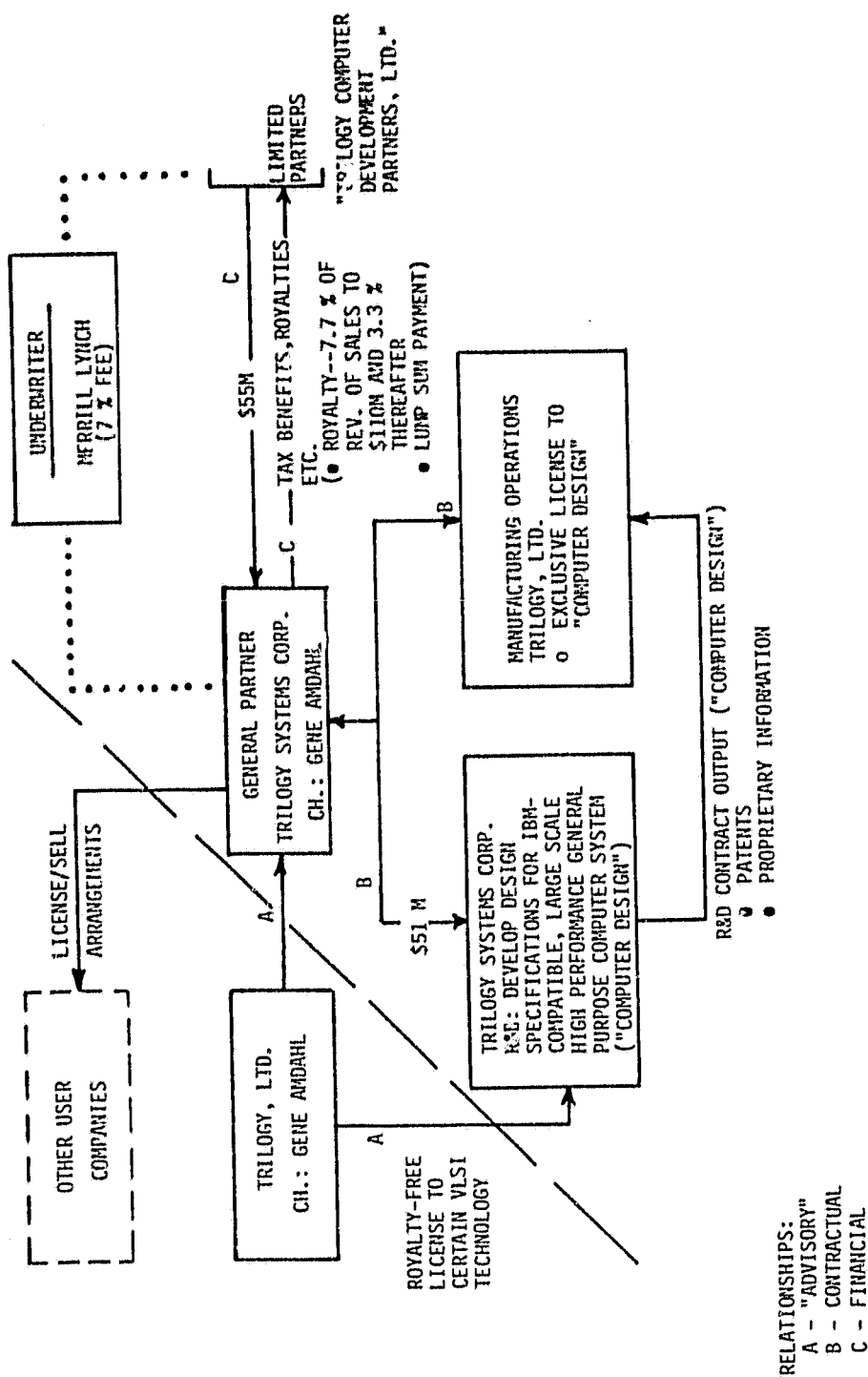


FIGURE 2.2 LIMITED PARTNERSHIP FOR TRIOLOGY TECHNOLOGY
(THE SPONSORING ORGANIZATION CONCEPT) (FROM REF.1)

ORIGINAL PAGE IS
OF POOR QUALITY

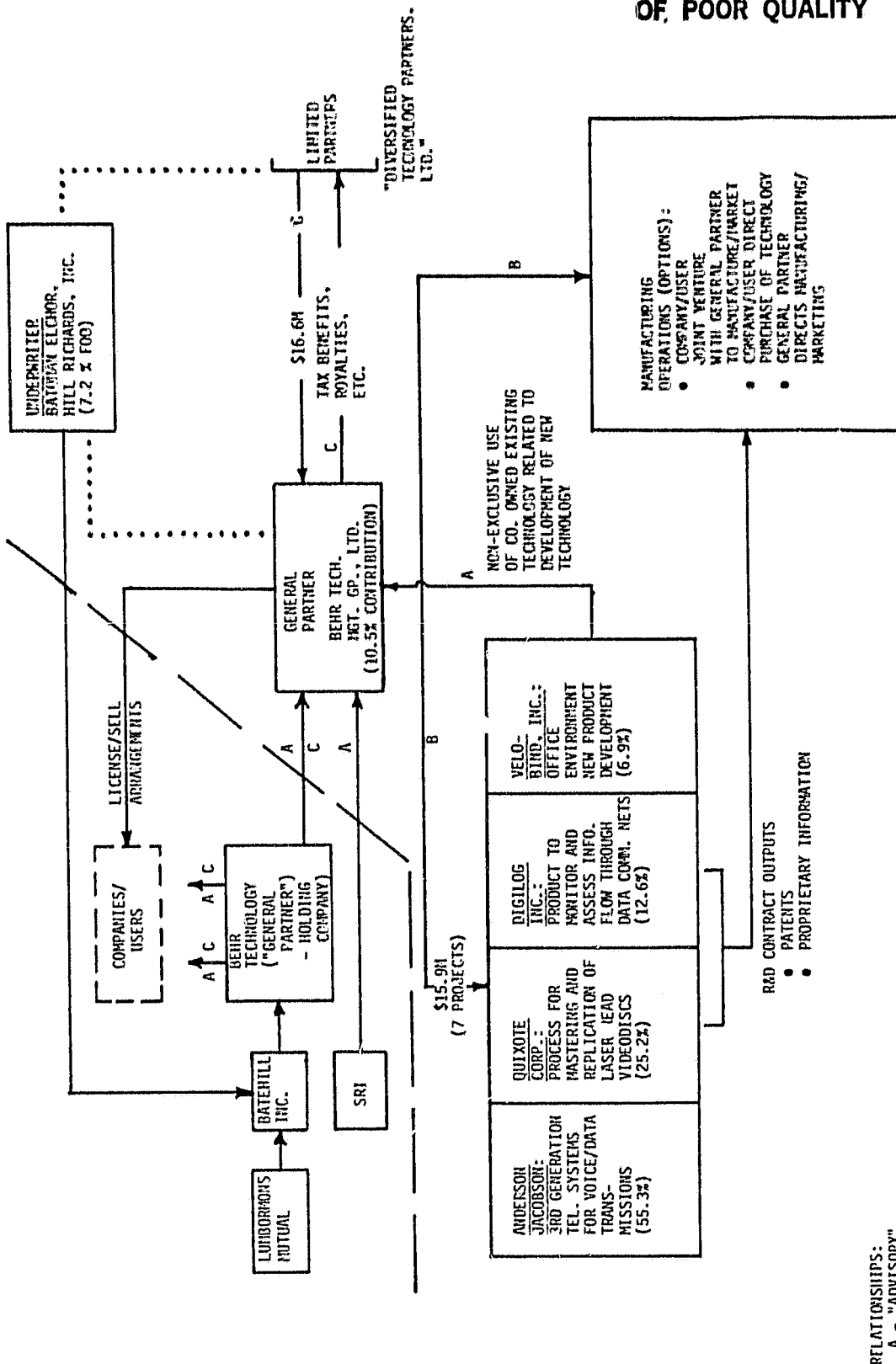


FIGURE 2.3 LIMITED PARTNERSHIP FOR BEHR TECHNOLOGY (THE "MULTI-PROJECT GENERAL PARTNERSHIP") (FROM REF. 1)

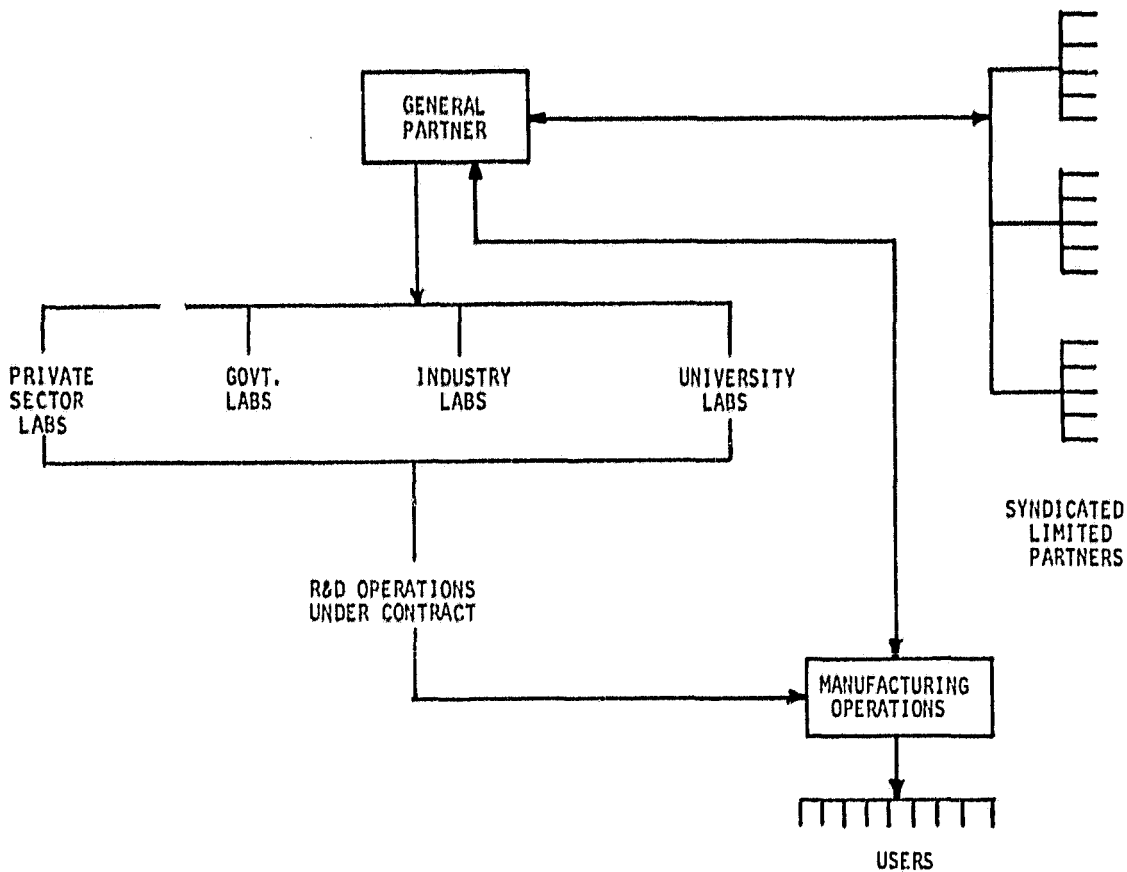


FIGURE 2.4 THE INDEPENDENT ENTREPRENEUR GENERAL PARTNERSHIP

require and complete licensing agreements, must select one or more organizations to perform the research, and must enter into contracts with prospective users of the newly developed technology.

Another version of the RDLP that might be beneficial for start-up companies that need both working capital and R&D funds is the R&D equity partnership. A new company may need to involve venture capitalists looking for equity interest as well as investors seeking tax advantages and this alternative uses both means of financing [1].

A typical partnership may proceed as follows. An inventor assigns or contributes an invention to a partnership and the limited partners contribute the capital. The partnership then engages a company to conduct the R&D, which it finances with the capital contributed by the limited partners. The company may have performed and completed some R&D relevant to the technology to be developed and the company may license this "base technology" to the partnership. Usually the company that conducts the R&D is directly related to the company that employs the inventor. Once the R&D has been completed the partnership owns the rights to the results of the project (usually an experimental model or prototype of a commercial product). It sells these rights to a company that has the capability to manufacture and market the resulting product. In return, the partnership receives cash royalties on product sales and/or stock in the company marketing the product [3]. In the case of the sponsoring company RDLP, the sale may be prearranged through the exercise of an option (lump sum or royalty) by the sponsoring organization.

The venture has two distinct phases. During the first, the R&D phase, agreements are drawn up, the investment is made, and the research and development is performed. If the work is successful and the prospective manufacturer opts to acquire rights to the new technology, the venture enters the buyout phase. The manufacturer produces and markets the product and the partnership receives payments for the technology rights in the form of royalties on sales, a lump sum and/or stock depending on the agreement.

The partnership may enter into agreements with other organizations, depending on the specific partnership. These agreements may be categorized as follows:

- a research and development agreement, where the partnership contracts with a second party, either affiliated or not, for the conduct of necessary research;

- a cross license and technology transfer agreement, whereby the partnership gains access to the basic technology needed to conduct the research;
- an agreement for an option to license the research results to a prospective manufacturer; or
- if the partnership plans to manufacture the product it may execute contracts with prospective buyers of its products [1].

The IRS must be satisfied that the partnership is structured as a partnership and not a corporation for the partners to receive tax benefits. For the RDLP to be considered a partnership, it must have at least two of the following four characteristics:

- unlimited liability (a creditor could recover from a General Partner);
- limited life (partnership terminates on death, bankruptcy, incompetence of a General Partner);
- owner management (General Partner has substantial interest in partnership);
- restricted transferability of interests (transferee does not become a partner without consent of other partners).

In addition, the IRS requires the following criteria be met before it will rule in advance that the RDLP is a partnership for tax purposes.

- the General Partner must have at least a 1% share of partnership income and loss;
- a nonrecourse lender cannot have an equity in the partnership by reason of the loan;
- deductions during the first two years may not exceed equity invested.

Furthermore, if the only General Partners are corporations the following three rules apply:

- limited partners may not own more than 20% of the stock of the general partners;
- the general partners must meet the net worth tests (usually 10-15% of partnership equity);

- purchase of partnership interest cannot give the buyer a right to purchase equity of the General Partner [1,8].

The following examples of RDLP's illustrate the wide range of forms that RDLPs can take.

Storage Technology Corporation (STC) produces electronic data storage equipment. In 1980 it had \$603 million in sales and \$45 million in net income. In February 1981 it established an RDLP and raised \$50 million to develop a high-performance computer using advanced very large scale integrated circuitry.

STC chose R&D partnership financing so it could use "more of its financial resources for the expansion of its existing lines and avoid the adverse impact on its near-term earnings which would result if the development program were to be funded solely by STC". This arrangement allowed STC \$25 million more net income over three years than if the funds had been raised from equity or cash from operations.

In October 1981, another RDLP raised \$40 million for STC to design, develop, manufacture and market a line of high performance IBM-compatible disk drives using optical recording technology to record data, and read data from a removable media. Partnership units were sold exclusively by a major brokerage firm and each partner had to invest a minimum of \$150,000. Proceeds to the partnership after placement fees and expenses were \$45 million. Benefits were to be allocated 99% to the limited partners and 1% to the General Partner.

STC agreed to allow its base technology to be used in exchange for a royalty free license to use the developed technology in non-computer applications. The company had already invested \$35 million to develop the base technology and related manufacturing capability and expected to spend \$30 million (from non-partnership funds) during the first three years of the contract to prepare for manufacturing and marketing of the product.

The development work was to be done by STC Computer Research Corporation (a subsidiary of a majority-owned subsidiary of STC) for direct cost plus 12% for G&A and expenses.

At the completion of the project STC might exercise its option to enter into a joint venture with the partnership to manufacture and sell the computers. If this is chosen STC will have an option to later purchase the technology from the partnership on a royalty basis. If not, the license for non-computer application expires and STC may opt to purchase the license for \$4 million. STC must also agree not to manufacture or market a high performance computer for three years.

Diversified Technology Partners Ltd. is a smaller RDLP with a multipurpose General Partner. This partnership was established in 1982 to fund R&D projects for four separate publicly-held companies. The four projects that were selected were to develop a voice/data PBX system, laser videodisc mastering and replication, data line monitors/simulators, and a proprietary office product. The total offering was \$16.5 million and minimum investment requirement was \$5,000. The four sponsoring companies are limited partners and have invested money in the partnership.

Each company has an option to enter into joint ventures with the partnership to manufacture and market the new products. Profits from the venture will be split between the company and the partnership 80%-20% for the first 14 months and 60%-40% after that. Each company is also obligated, if necessary for the project, to loan the venture money up to a certain pre-specified amount.

If the companies exercise their joint venture option, they then have the option to buy the technology 13 months after the first product is shipped or the invention has been "reduced to practice", by paying royalties on a specified schedule.

Trilogy Computer Development Partners Ltd. is a wholly owned subsidiary of Trilogy Limited, a Bermuda holding company (See Figure 2.2). The two companies established an R&D partnership in August 1981 to raise money to design a large scale, high-performance general purpose computer system. Since its formation in 1980, Trilogy Limited has engaged primarily in raising capital and organizing the corporate structure. Trilogy Systems Corporation has engaged mainly in obtaining facilities and recruiting personnel to begin development of the computer design.

The size of the offering was \$55 million and the minimum investment was \$10,000. The partnership agreement stipulated that profits and losses would be allocated 99% to the limited partners and 1% to the General Partner. Trilogy Limited granted the partnership an exclusive, worldwide royalty free license to use the base technology. Trilogy Systems Corporation performs the development work at cost plus a profit varying from 0-15% of cost, as determined by a formula.

Trilogy Limited may exercise an option, one year and one day (good until 1988) after the technology is reduced to practice, to obtain an exclusive, worldwide license to use the computer design and sublicense it. The company may choose to make royalty payments or a lump sum payment to the partnership. The partnership has the option of receiving stock instead of cash or a combination of both.

In June 1983, additional shares of stock were sold to fund completion of the project [4,6].

2.3 Advantages of RDLPs

R&D limited partnership financing has several advantages over other types of financing to the company sponsoring the research. The major advantages include:

- Risk Transfer: The risk is borne by the limited partners instead of the corporation. If the project fails the company is under no obligation to the partnership. It is the partnership funds that are at risk which is

offset by the partners' tax benefits and large potential royalties (or other buy-out options).

- Less Dilution and Retention of Control: When the research is funded via an RDLP rather than stock sales there is less dilution to shareholders and therefore the company retains greater control over the direction of the product's development as well as the direction of the company.
- Reacquisition Rights: If the project is a success, RDLP arrangements allow the company to acquire all rights to the product without risking its capital in an uncertain R&D organization.
- Better Cash Flow: Avoids initial debt-service requirements. Since royalty payments for R&D partnership funds begin after the successful completion of the project and the start of sales, the company's cash flow is not impacted until inflows from the sales of products have commenced [6]. Cash flow impacts occur only if the R&D program has been successful and the option is exercised to acquire the technology.
- Accounting Treatment: Company's earnings during the R&D phase are not effected by the R&D efforts since the company's R&D expenditures are offset by income from the R&D contract. If structured correctly an R&D partnership allows for "off balance sheet financing", which means that funds received from the partnership are not shown as debt on the financial statements. The debt-equity ratio is improved compared to debt financing, which may result in its receiving more credit. This also makes the company look healthier to shareholders. Table 2.1 presents a simplified comparison of funding a \$1,000,000 R&D

TABLE 2.1 SIMPLIFIED COMPARISON OF ALTERNATIVE FINANCING SCHEDULES (R&D PHASE ONLY)			
FINANCIAL ITEM	TYPE OF FINANCING		
	R&D Partnership	Debt Financing	Equity Financing
Contract revenue	\$1,100,000		
R&D expense	(1,000,000)	\$(1,000,000)	\$(1,000,000)
Interest expense		(150,000)	
Pre-tax effect	100,000	(1,150,000)	(1,000,000)
Income taxes (at 50%)	(50,000)	575,000	500,000
R&D tax credit*		100,000	100,000
After-tax effect on earnings	\$ 50,000 =====	\$ (475,000) =====	\$ (400,000) =====
*Assumes that 80% of expenditures qualify.			

project with a cost-plus-10% R&D contract, and borrowings at 15% interest or equity. Only the R&D phase is illustrated [3,6,8].

- Tax Advantage: With R&D financing all of the payments to the investor are likely to be entirely deductible.* With debt financing, only the interest is tax deductible and with equity financing neither dividends nor redemption payment is deductible [8].

The comparison of debt and RDLP financing of a corporation's R&D program is further elaborated upon in Table 2.2 where a \$1,000,000 R&D activity (no fee) is considered. Both an R&D success and R&D failure case are considered for both types of financings. It is important to note the consequences to the corporation for both the success and failure cases. A basic distinction is immediately apparent between the debt and RDLP financing. In the debt financing case there is no revenue (only the R&D phase is considered) whereas in the RDLP case there is

* Although royalties paid on the purchase of patent rights are capital expenditures, if the payments are based on sales and made over the life of the technology, the royalties paid will usually be deductible as a reasonable measure of amortization [12].

TABLE 2.2 SIMPLIFIED COMPARISON OF DEBT AND RDLP FUNDING				
ITEM	DEBT FUNDING		RDLP FUNDING	
	R&D SUCCESS	R&D FAILURE	R&D SUCCESS	R&D FAILURE
REVENUE FROM SALES	-	-	1,000,000	1,000,000
INTEREST EARNED*	50,000	50,000	50,000	50,000
ROYALTIES PAID	-	-	NPVR	-
NET REVENUE	50,000	50,000	1,050,000-NPVR	1,050,000
COST OF SALES	-	-	-	-
R&D EXPENSE	1,000,000	1,000,000	1,000,000	1,000,000
DEPRECIATION	-	-	-	-
INTEREST EXPENSE	100,000	100,000	-	-
MARKETING/SALES EXPENSE	-	-	-	-
BEFORE TAX PROFIT (LOSS)	(1,050,000)	(1,050,000)	50,000-NPVR	50,000
INCOME TAX (CREDIT)	(525,000)	(525,000)	25,000-NPVR/2	25,000
INVESTMENT TAX CREDIT	-	-	-	-
R&D TAX CREDIT**	200,000	200,000	-	-
AFTER TAX PROFIT	(325,000)	(325,000)	25,000-NPVR/2	25,000
LOAN	1,000,000	1,000,000	-	-
AFTER TAX PROFIT	(325,000)	(325,000)	25,000-NPVR/2	25,000
DEPRECIATION	-	-	-	-
INCREASE IN PAYABLES	-	-	-	-
CASH INFLOW	675,000	675,000	25,000-NPVR/2	25,000
LOAN REPAYMENT	1,000,000	1,000,000	-	-
INCREASE IN RECEIVABLES	-	-	-	-
INCREASE IN INVENTORY	-	-	-	-
CAPITAL EXPENDITURES	-	-	-	-
CASH OUTFLOW	1,000,000	1,000,000	-	-
NET CASH FLOW (I.E., PROJECT COST)	(325,000) + NPV OF PROJECT CONTINUANCE	(325,000)	25,000-NPVR/2 + NPV OF PROJECT CONTINUANCE	25,000
*ASSUMED AVERAGE REMAINING LOAN BALANCE = 0.5 x LOAN VALUE OR 0.5 x RDLP FUNDS RECEIVED. **ASSUMES THAT 80% QUALIFIES.				

revenue in the amount of \$1,000,000 -- the contract funds received from the partnership for performing the R&D. Table 2.2 indicates primarily the transactions during the R&D phase but with some consideration for the buy-out and subsequent operations phase. For example, NPVR represents the net present value of royalties paid or lump sum buy-out that results from exercise of the buy-out option and subsequent operations. NPV represents the net present value of cash flows of the sponsoring organization from continuing operations.

Consider the debt funded R&D success path. Net revenue is in the amount of \$50,000 assuming \$1,000,000 is immediately set aside or committed for the project.

The expenses consist of the R&D expense and interest on the debt. Before tax profit is $-\$1,050,000$. With an income tax credit of $\$525,000$ and an R&D tax credit of $\$200,000$ (assuming 80% of the R&D qualifies for the R&D tax credit), there is an after tax loss of $\$325,000$. The after tax loss coupled with the loan and loan repayment results in a net cash flow (or project cost) of $-\$325,000$ plus the present value of the cash flows resulting from the project continuance (i.e., manufacture and sales). The R&D failure case is similar with the exception of the project continuance component which does not exist and the cost to the company is $\$325,000$.

In the RDLP funding and R&D success case, a contract is received for $\$1,000,000$. When the option is exercised (or as a result of its being exercised) royalty or other payments are made having a present value of NPVR. Thus, net revenue is in the amount of $\$1,050,000 - \text{NPVR}$. This combined with the R&D expense of $\$1,000,000$ and income tax yields an after tax profit of $\$25,000 - \text{NPVR}/2$ which is also the net cash inflow. Since there are no cash outflows (for example, loan repayment), the net cash flow of the project is $\$25,000 - \text{NPVR}/2 + \text{NPV of project continuance}$.

The R&D failure case is similar but with the exception that the option is not exercised and NPVR and NPV of project continuance are both zero with the result that the net cash flow (i.e., project cost) is a positive $\$25,000$. This must be contrasted to the $-\$325,000$ in the debt funded R&D failure case.

Clearly the role of the RDLP financing is to limit (or eliminate) the downside risk but at the price of reducing the upside potential.

The value of RDLP financing relative to debt financing to the sponsoring corporation can be established in more general terms as follows:

Let BTP = before tax profit (\$)

ATP = after tax profit (\$)

CF = cash flow (\$)

RD = R&D expense and RDLP investment (\$)

IR = interest rate (%)

NPV = net present value of cash flow of project continuation (\$)

NPVR = net present value of royalty stream or cash buy-out (\$)

P = probability of success (a prior subjective judgement
of R&D undertaking)

K = multiple of R&D investment to be returned to RDLP
limited partners (i.e., cash-on-cash ratio and is typically
in the range of 3 to 5)

Using the above definitions, Table 2.2 may be generalized as

Debt Funding

R&D Success:

$$CF = -0.3 \times RD - 0.0025 \times IR \times RD + NPV$$

R&D Failure:

$$CF = -0.3 \times RD - 0.0025 \times IR \times RD$$

RDLP Funding

R&D Success:

$$CF = 0.0025 \times IR \times RD - 0.5 \times NPVR + NPV$$

R&D Failure:

$$CF = 0.0025 \times IR \times RD$$

Therefore the expected value, \bar{V} , of RDLP financing relative to debt financing is obtained as

$$\begin{aligned}
 \bar{V} = & [(0.0025 \times IR \times RD - 0.5 \times NPVR + NPV) \times P \\
 & + (0.0025 \times IR \times RD) \times (1-P)] - \\
 & [(-0.3 \times RD - 0.0025 \times IR \times RD + NPV) \times P + \\
 & (-0.3 \times RD - 0.0025 \times IR \times RD) \times (1-P)]
 \end{aligned}$$

which reduces to

$$\bar{V} = (0.3 + 0.005 \times IR - 0.5 \times P \times K) \times RD$$

where $K \times RD$ has been substituted for $NPVR$ -- in other words 3 to 5 times the R&D investment must be returned to the investors. This is illustrated graphically in Figure 2.5. It is clear, from an expected value point of view, that RDLP financing is most advantageous when undertaking risky R&D projects.

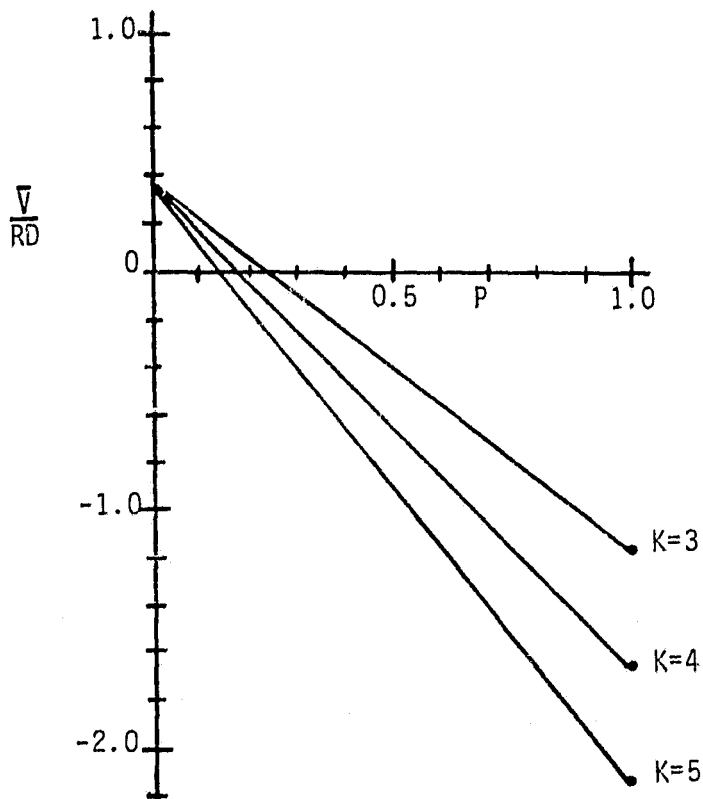


FIGURE 2.5 NORMALIZED VALUE OF RDLP FINANCING COMPARED TO DEBT FINANCING IN TERMS OF LIKELIHOOD OF R&D PROJECT SUCCESS

It should be noted that the above is based upon expected value and does not allow for the risk avoidance preferences of the sponsoring corporation. For example, if there is a strong desire not to lose any money on the R&D project and if this is more important than making larger profits (as impacted by the royalty payments) then the family of curves (in Figure 2.5) denoted by $K = 3, 4$ and 5 rotates counterclockwise (around the intercept with the V/RD axis) making it attractive to pursue RDLP funding for projects that have higher likelihoods of R&D success.

Turning attention to the investors or limited partners of the RDLP, there are several advantages for the investor in an R&D limited partnership including:

- Current Tax Shelter: A large percentage of the investment can be deducted from ordinary income if the partnership is structured correctly. This reduces the cost of the investment and therefore increases the potential return [3,6,8].
- High Rates of Return: Most RDLPs offer high after-tax rates of return on the investors' net investment [3,6]. This is of necessity determined by the negotiations in the market phase. Historically, cash-on-cash ratios (total cash returned relative to cash invested) of 3 to 5 have been achieved or are at least set as the goal.
- Returns Taxed at Capital Gains Rates: Income from the sale (lump sum or royalty payments) of technology rights from successfully completed projects may be taxed as long-term capital gains rather than as ordinary income [6,8].
- Earlier Payout: Investors begin receiving cash returns as soon as sales of the product commence, independent of company profits (in a

royalty type of buy-out). This protects their returns from the uncertainty of the long-term profitability of the company.

- Potential Equity Position: Many R&D partnerships provide investors with the option to receive stock in the company in exchange for the rights to the technology, allowing them to make an equity investment with the added advantage of up-front tax benefits [6].

2.4 Disadvantages of RDLP's:

There are also several disadvantages in RDLP financing facing the sponsoring corporation as well as the RDLP limited partners. From the sponsoring company's point of view the disadvantages include:

- High Cost of Capital: Since the R&D project is risky the investor requires a higher return than in less risky ventures, and so if the project is successful and the company acquires the technology it must pay royalties on sales and the cost to the company may be high. If royalty provisions are too high, they can eat into profit margins. The true cost to the company depends upon the a priori likelihood of R&D project success and the firm's risk avoidance preferences as discussed in Section 2.3.
- Restricted Use: Funds from the RDLP get favorable tax treatment when they are used to fund R&D. Other expenses required for the project (for market surveys or equipment) do not receive favorable treatment and the company may need to secure equity or debt financing to fulfill all its needs [6].

- Expensive to Establish: RDLPs have been expensive and time consuming to set up and require expertise from underwriters, attorneys, accountants and the general partner. After formation, partnership records must be maintained and tax returns filed [5,8]. For small RDLPs, it is likely that set-up costs may be reduced as familiarity is gained with their structuring as has been the experience with other business ventures (for example, real estate limited partnerships).

From the RDLP limited partner's point of view there are also disadvantages which include:

- Lack of Liquidity: Interest in the partnership is not a marketable security and is generally restricted as to transfer [6,8].
- Additional Funding May Be Required: If the R&D project requires more money, investors may have to contribute more, or new partners may be found (this would cause dilution to existing partners). This funding problem may be addressed in the initial partnership agreement stating the specific conditions under which the partners would have to contribute additional funds and the consequences if the funds were not provided.
- Lack of Management Control: Investors (the limited partners) have no say in business decisions or management.
- Possible Limitation on the Upside Potential: The company may place a "cap" on the investors' participation through its repurchase option [4]. This however is part of the option agreement and would normally be taken into account by the partners when making their investment decisions.

- Vague Tax Laws: Tax laws affecting R&D partnerships are complicated and sometimes vague. RDLP's may be subject to greater scrutiny by the IRS. If the IRS does not accept the partnerships tax benefits the rate of return may be too low for the risks associated with the venture.

2.5 Antitrust Implications

RDLP's are not entitled to special antitrust immunity but receive the same consideration as collaborative R&D efforts in general. Both the courts and federal enforcement agencies recognize the procompetitive potential of collaborative R&D and apply "rule of reason" type of analysis that is sensitive to the procompetitive benefits of joint R&D. Only when the joint venture is likely to be anticompetitive, do the antitrust laws condemn the venture.

When the RDLP limited partners are firms that are normally competitive, R&D ventures can have two different anticompetitive effects according to the Justice Department. First it can serve as a device through which participants can coordinate prices and current production in some market in which they compete. However, this danger is mitigated by the limited scope (R&D only) and limited duration of such ventures. Factors taken into consideration in judging whether such ventures are anticompetitive include market concentration in the products in which participants compete, market share of the joint venture, the nature of the R&D and its relationship to goods or services currently produced by the participants, and how much information on current prices, cost and/or output is exchanged among the members. Also, the structure of the joint venture is important in determining the risk of collusion. Joint venture analysis also considers the potential efficiencies that the joint venture can be expected to produce.

The second potentially anticompetitive effect relates to innovation. It is possible that if the venture includes too large a fraction of firms capable of conducting the same or similar R&D, the incentives to innovate could be reduced. The reasoning is that if a large enough percentage of the total potential performers of a particular type of R&D collaborate, there is less of a desire to succeed, because the competitive advantage of successful R&D to each participant is less when it must be shared. As long as there are at least five other commercial entities outside the partnership capable of undertaking comparable R&D, the venture should be free of antitrust concerns. If the joint venture comprises more than 15% of the market however, it is up to the joint venture to prove that a venture of its size is required to attain significant economics.

Even a joint venture composed of all possible competitors might be accepted if it could be shown that only one such entity could efficiently service the market. If a joint venture that includes over 51% of the market is accepted as a natural monopoly and secure from antitrust litigation, a problem remains. Market participants that are excluded from the venture may raise an argument on equitable grounds that they should be allowed access to the venture, because without being included in the venture they will not have the ability to participate in R&D that is integral to their future competitiveness. On the other hand, if the joint venture must accept all the firms in the industry, the incentives of the members to invest in R&D may be reduced or destroyed. Although the problem has not been resolved yet, some courts have accepted the argument that when a joint venture is a natural monopoly, access to the venture must be open to all competitors who are willing to share in the cost risk of the venture [1].

2.6 Tax Implications

Unlike corporations, partnerships are not taxable entities. Items of partnership income and loss are allocated to the partners who combine these items with other items of income and loss on their individual tax returns. In this way, investors can use their share of any partnership losses to offset other income they have earned thereby reducing their total taxable income, and, therefore their taxes. This stands as a major incentive to investment in RDLPs [3,5,6,8].

Certain criteria must be met for the RDLP to be treated as a partnership by the IRS and these have been set out in section 2.2. In addition, funds must be used only for R&D activities that qualify under Section 174 of the Internal Revenue Code or the limited partners may not be able to write off their investment against their ordinary income. Qualifying research expenditures are defined as "expenditures incurred in connection with the taxpayer's trade or business (the business may be a new venture that has not yet offered products for sale) which represents research and development costs in the experimental or laboratory sense incident to the development of an experimental or pilot model, a product, an invention or improvement of existing property of the type mentioned". This excludes funds spent on marketing, production, to pay off creditors or for other types of R&D expenses. A deduction for the cost of work performed on the taxpayer's behalf is permitted. The partnership must bear the risk of failure of the project, in order to be entitled to the tax benefits. Therefore the partnership must not receive any "performance guarantee" [3,8].

Income from the sale of the technology may be taxed as capital gain (taxed up to 20%) by the partners rather than as ordinary income (taxed up to 50%), if certain conditions hold. To qualify for capital gains treatment under Section 1235 (of the Internal Revenue Code) there must be a transfer of "all substantial rights"

to the technology by a holder of the technology as long as it is not to a related party, family member or 25% owned entity. A holder is defined as an individual who created the technology or acquired an interest in it from the creator in exchange for consideration paid in money or money's worth. A corporation or partnership does not qualify as a holder, but individual partners do and corporate partners in an RDLP do not qualify.

Section 1235 applies to technology that is patentable. The agreement transferring the technology should provide for the transfer of all rights to use, manufacture, and sell the product or products throughout the world during the period of the technology's useful life, and the ability to prevent disclosures, including any by the RDLP itself, of the technology to unauthorized persons.

The company sponsoring the R&D has tax considerations as well. Payments from the partnership for performance of the research contract are generally considered, for tax purposes, as revenue in the year it is received by the sponsoring company. The company tries to offset this revenue with its own expenses, incurred in working for the partnership to develop the technology. This may be a problem because often payments are received somewhat in advance of work to be performed, due to the tax deduction concerns of the investors. This problem may be alleviated either by creating an independent corporate entity (with its own accounting year) to undertake the research, or by scaling R&D contract payments over the estimated period of performance. Where performance must be complete by the end of the following tax year, a deferral election may be made by accrual method companies to alleviate the problem [5,8].

If the company exercises an option to purchase rights to "patentable property" the company is acquiring an intangible asset and so the company's

purchase payments should be regarded as capital expenditure and taxed accordingly. Judgments and uncertainties exist in this area and the result may often depend on the contractual arrangements. Where the royalty arrangement is indefinite there is support for the deductibility of royalties as incurred. Where there are minimum or capped royalties there may be tax exposure for an amortization period which could produce tax deductions slower than the payment of royalties [5,8].

The company may amortize the cost of acquiring the technology rights over the estimated life of the asset. Under certain circumstances the annual amount amortized could be equal to royalty payments made to the partnership.

If the company uses an R&D partnership to finance a project it cannot claim R&D tax credits (Economic Recovery Act of 1981), as it could if it financed the project itself, because the partnership is financing the project. However, the partnership cannot claim the tax credits either because the Act requires the taxpayer be "engaged in a trade or business". In deciding which type of financing to use for an R&D project, the company should consider the impact of the R&D tax credit [3].

2.7 Formulation of the RDLP Business Plan

One of the initial steps in establishing the RDLP is the clear identification of the technology to be developed. This step is necessary because the partnership needs to have available to it certain basic technology as a building block upon which to develop the new technology. The partnership may obtain the basic technology through outright purchase; however, a frequent practice is for the partnership to obtain the technology through a license agreement from one of the other parties. This practice often involves an arrangement whereby the party makes the basic technology available to the partnership on a nonexclusive royalty free basis for use in the R&D project in return for suitable consideration.

Another important step in the preliminary stage is for the organizer of the partnership to develop a business plan to serve as a foundational document for the R&D project. A well prepared, comprehensive plan should be considered essential in assisting fund raising efforts and in preparation of partnership formation agreements. Some of the important elements of this document are outlined below:

- Statement of Objectives to include an extensive analysis of the R&D project identifying such items as the specific technology to be developed, the availability of basic technology, the amounts of funds necessary to complete the project, the manner in which funds are to be expended, and the availability of facilities, equipment and personnel to accomplish the R&D objectives.
- Technical Evaluation to determine whether or not the technology is possible. This should include an evaluation of whether the research and development timetable and budget is reasonable and whether the developed technology will reach the market on a timely basis with a potential to meet the partnership's investment return objective. The evaluation may be conducted by the organizer's own business and technical advisors or preferably independent consultant or research firms.
- Market Analysis to evaluate the perceived existing or potential market for the developed technology. This study should detail the anticipated demand, estimated revenues, and probable production costs of the technology. The analysis should also include an assessment of potential competition and the effects of alternate technology and obsolescence on the technology to be developed.

- Development Plan setting forth a detailed research budget including a description of the work to be done and providing benchmarks for the completion of the project. Such benchmarks should identify the performance characteristics of the product or technology to be developed, especially if advance purchase contracts are involved. This plan may serve as a basis for the R&D agreement between the partnership and the research contractor and thus it should outline the obligations of the contractor in performance of the R&D effort, the manner in which the General Partner will monitor the project, and the rights of the partnership, subject to any license agreement, to ownership of the technology developed under the project.
- Manufacturing and Marketing Plan to determine which party or parties will market, manufacture and license the technology in the event the project results in a successfully developed technology. Typically, the party which licensed the basic technology to the partnership retains an option to acquire the rights to manufacture and market the new technology. The party, in exercising the option, will usually be obligated to pay the partnership royalties based upon sales of products or processes embodying the technology. The amount and timing of royalty payments should be specified in the plan. Generally, minimum royalty payments should be required to encourage exploitation of the new technology. But care must be exercised that the specification of minimum payments does not negate the risk which would lead to the IRS disallowing the tax benefits.

The above list is by no means exhaustive. Other items which may be considered in the foundational document include:

- Investment objectives
- Allocation of profits and losses
- Risks and associated factors
- Conflicts of interest
- Tax considerations
- Disbandment considerations

Due to the importance of a well conceived business plan, an inexperienced organizer should obtain expert assistance in the preparation of such a document [1].

3. ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE PROGRAM

3.1 Introduction^{*}

The National Aeronautics and Space Administration (NASA) is conducting an Advanced Communications Technology Satellite (ACTS) Program to advance the high risk technology required to ensure continued United States' preeminence in the field of satellite communications. The objectives of the ACTS Program are to develop and validate the technology required to enable growth in the capacity and effective utilization of the frequency spectrum and to effect new and innovative uses for satellite communications. NASA and Congress are considering the start of the flight experimentation phase of the program. If the flight experimentation phase is approved the ACTS spacecraft may be scheduled for launch into geostationary orbit by the Space Transportation System (Space Shuttle) in 1988 or 1989. Figure 3.1 indicates the ACTS program schedule. (Figure 3.1 and the following discussion are based upon the program previously envisioned in References 9 and 10.)

The ACTS communications technology payload would incorporate the high risk technologies necessary to permit more efficient use of orbit and spectrum resources and to allow for new forms of communication data transfer. Operation would be in the 30/20 GHz frequency band. A nominal two-year period for experiments was planned. The technology developed under the ACTS Program will be usable in multiple frequency bands and will be applicable to a wide range of future communication systems required by NASA, other government agencies and U.S. industry.

As previously conceived, a primary goal of the ACTS Program was to make available to the public and private sectors (corporations, universities and

^{*}Based upon References 9 and 10.

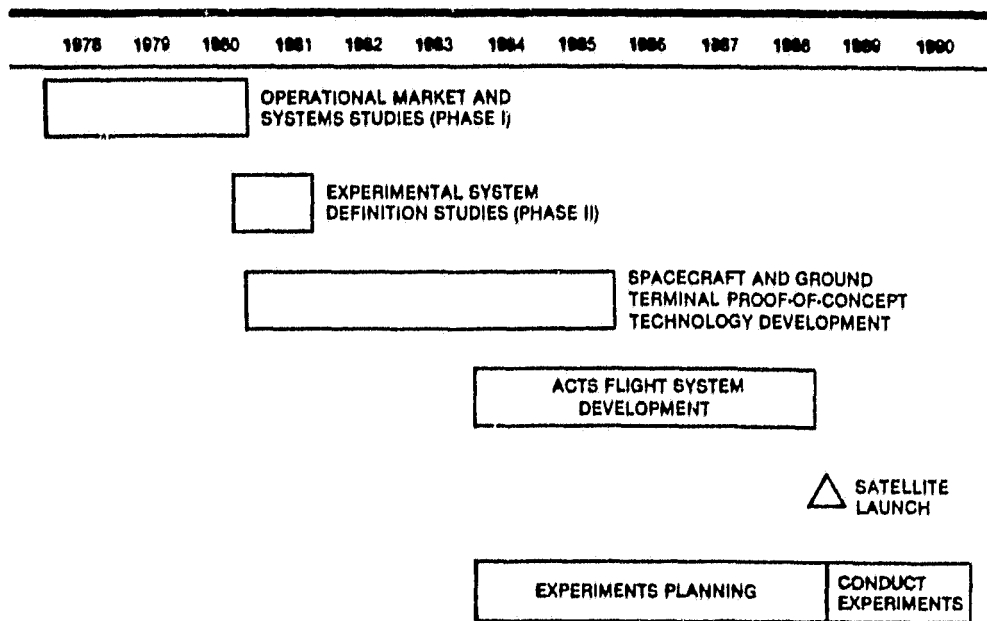


FIGURE 3.1 ACTS PROGRAM SCHEDULE

government agencies) the capabilities of the ACTS spacecraft for experimentation. It was the intent of NASA to consider all experiments technically and scientifically relevant to the basic objectives of the ACTS Program and for which the ACTS system could accommodate. NASA would develop the flight system and provide access to the ACTS space segment at no cost to the experimenter. Each experimenter would be responsible for the conduct and funding of their experiment, including ground terminal equipment and operations.

3.2 Review of ACTS Program

The Advanced Communications Technology Satellite Project included the design, development and operation of an Advanced Communications Technology Satellite System. The ACTS System included the ACTS spacecraft, a combined Master Control Station (MCS) and a single NASA ground station. The experimenters would provide their own earth terminals necessary to conduct their respective technology experiments. Figure 3.2 is a schematic of the ACTS System.

The ACTS spacecraft was to be shuttle launched in 1988 into geostationary orbit for a two-year experimentation mission. The payload was to have a nominal

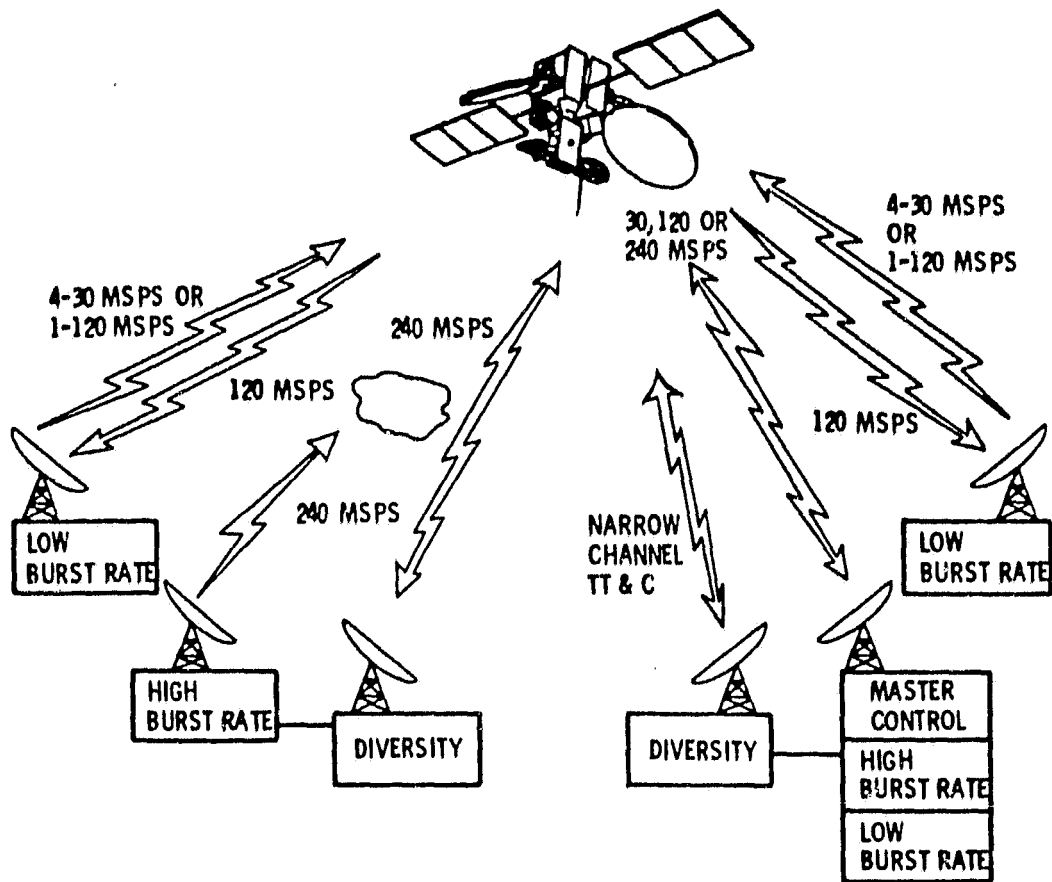


FIGURE 3.2 SCHEMATIC OF ADVANCED COMMUNICATIONS
TECHNOLOGY SATELLITE SYSTEM
(FROM REFERENCE 10)

weight of 160 kilograms (350 pounds). The advanced technology to be incorporated into the communications payload included a high gain multibeam antenna, a high speed IF matrix switch, a baseband processor, low noise receivers and multipower traveling wave tubes transmitters. Operation would be in the Ka (30/20 GHz) frequency band; 27.5 to 30.0 GHz uplink and 17.7 to 20.2 GHz downlink. The ACTS System was to be capable of providing communications between ground terminals having either low burst rate (LBR) channels or high burst rate (HBR) channels.

The multibeam antenna and its associated components would provide both scanning and fixed beams. Scanning beam/Low Burst Rate coverage would be provided simultaneously by two independent beams to two contiguous sectors and

isolated nodes outside of either sector but within CONUS. Nominally, the scanning beams would each cover an area of approximately 10 percent of CONUS. The coverage provided by the fixed beam/HBR links could include the area covered by the LBR scan beams (which may be stopped to provide fixed beam), a fixed beam on MCS as well as two additional fixed beams which are not part of the scan beam coverage pattern.

The NASA Ground Station would consist of a primary station with both high and low burst rate capability as well as a diversity station for telemetry, tracking and command (TT&C) only and a terrestrial link interconnect between the primary and diversity sites. All master control functions for the ACTS system would be provided by the NASA Ground Station and would be referred to as the Master Control Station (MCS). The Master Control Station would provide spacecraft control, network control and experiment management and data recording. All message traffic would be requested, set up and programmed by the MCS. Furthermore the MCS would distribute all the information necessary to support both the HBR and LBR communication links and coordinates the incorporation of rain compensation measures. Channel assignments were to be made on a demand basis according to a reservation scheme for both HBR and LBR channels under control of the MCS where the access link is via the satellite. Maintenance of synchronization would be accommodated in a closed loop fashion by each terminal. The terminals and the flight system are discussed further below.

High Burst Rate Ground Terminal

The fixed beams/High Burst Rate (HBR) system would provide communications among the HBR terminals on a TDMA basis. Interconnectivity among different beams would be accomplished by the IF-matrix switch on the satellite, which allows TDMA traffic bursts transmitted in one beam to be routed to others

as required by the network traffic plan. The switch configurations used for beam interconnections would be programmable and would be changed to optimize traffic flow. A burst may be sent to multiple destinations by implementing point-to-multipoint or broadcast switch connections on the satellite. Interconnectivity between the HBR terminals would be provided for up to three active nodes. For the ACTS System, a node is defined as one or more HBR stations within the same beam. Within the active three node HBR network, six HBR stations would be capable of operating with up to three stations per beam. All HBR beams would use the same frequency. The coverage provided for the HBR links would include the areas covered by the LBR scan beams (which may be stopped to provide fixed beams), a fixed spot beam on MCS location, and two additional fixed beams which are not part of the scan beam coverage.

The uplink and downlink burst rates would be nominally 240 MSPS with a minimum nominal throughput capacity (information rate) including overhead of 240 MBPS. The system would have the capability to operate at 500 MSPS but at a reduced availability. Uplink and downlink gains would be 52 dB. Rain compensation would be provided by both uplink and downlink power augmentation and by site diversity to maintain the BER at less than 10^{-6} . Power augmentation would be automatically implemented to accommodate uplink rain fades of up to 18 dB and/or downlink rain fades of up to 8 dB whenever the rain fade rate is less than 1 dB/second. The HBR system would be designed to provide 240 MSPS burst rate service to ground terminals having a nominal antenna diameter of five meters, a High Power Amplifier (HPA) of approximately 400 watts and a noise figure of 4 dB (440K) for the Low Noise Receiver (LNR).

Low Burst Rate Ground Terminal

The scanning beam/Low Burst Rate (LBR) system would provide communications among the LBR terminals on a FDM/TDMA basis through the use of a multibeam antenna and a baseband processor (BBP) on board the flight system. The transmitted uplink bursts are frequency demultiplexed, demodulated, decoded (if appropriate), buffered, processed (digitally routed), reformatted, encoded (if appropriate) and remodulated on the spacecraft and transmitted to the designated areas. Interconnectivity between LBR terminals would be provided via the baseband processor on a circuit switched basis with a minimum equivalent circuit capacity of one 64 Kbps channel. That is, individual message traffic could be routed from any LBR terminal to any other LBR terminal. The LBR system would also be capable of distributing LBR traffic from any LBR terminal to a group of terminals. After the burst is received on-board by the BBP, individual messages from that terminal are sorted by destination and each message is then downlinked to the proper location.

LBR coverage would be provided simultaneously by two orthogonally polarized independent flight system scanning beams and one fixed beam on the MCS location. Each scanning beam would provide complete coverage for a sector which included approximately ten percent of CONUS as described above.

The LBR system would accommodate, as a minimum, 40 LBR terminals within the total scanning beam coverage area during one scan period. In addition, a maximum of 30 LBR terminals would be capable of operating within one scan period of either scanning beam. Provision would be made to accommodate up to 6 LBR terminals per beam dwell location. The total throughput capacity of the LBR system without forward error correction (FEC) would nominally be 360 MSPS. Each scanning beam would have a maximum throughput capacity of 240 MBPS, which is provided on the uplink by a combination of 30 MSPS and 120 MSPS burst

rate FDM channels. The system would be capable of switching between the 30 MSPS and the 120 MSPS burst rate channels within a beam dwell. On the downlink, data would be transmitted over a single 240 MSPS burst rate channel. Minimum uplink and downlink gain would be 48 dB. Rain compensation would be provided by forward error correction (FEC) and burst rate reduction. Total link margins with FEC and burst rate reduction would be 15 dB on the uplink and 6 dB on the downlink. FEC and burst rate reduction can be applied on an automatic basis to rain degraded uplinks and/or downlinks in order to maintain the BER at 10^{-6} . The total BBP uplink or downlink data rate FEC capacity would be a minimum of 18.9 MSPS (equivalent to 3 T2 channels).

The LBR system would be designed to provide services to the 120 MSPS burst rate ground terminals having a nominal antenna size of 5 meters, a HPA of approximately 50 watts and LNR noise figure of 4 dB. LBR service for the 30 MSPS burst rate ground terminals is designed for a nominal antenna size of 3 meters, a HPA of approximately 25 watts and a LNR noise figure of 4 dB. It is not intended that the HBR and LBR systems operate simultaneously, although limited operation of the two may be possible. In addition, provisions for communication services during eclipse and direct sun outages are not planned.

Flight System

The flight system can be assumed to be located nominally at 100° West longitude in geostationary orbit. The final orbit location would be specified at a later date. The desired orbit location of the flight system would be maintained to within ± 0.05 degrees in both North-South and East-West directions for the mission duration.

The MCS would provide on orbit TT&C. The MCS would provide and perform all functions associated with the on-orbit control and operation of the flight system

(mission operations), with the control and operation of the communications network (network operations) and with the conduct of the experiments. Facilities at the MCS would include automatic data processing equipment, receiving and transmitting equipment and display equipment. Spacecraft performance data, including that of the multibeam communications subsystem, would be recorded and distributed to the experimenters as part of the experiment operation system.

NASA issued a Notice of Intent (NOI) for experiments in March 1983 in order to identify those organizations interested in experiments with the ACTS and determine insofar as possible what the experiment characteristics and requirements would be. Experiments were invited to provide quantitative on-orbit performance data as well as reliability and stability measurements related to the advanced technology components implemented in the flight system and associated ground terminals.

A number of representative experiment subcategories have been identified for the ACTS Experiment Program. These experiments subcategories and their relationship to the technology considered for development within the ACTS Program are briefly described below. It should be noted that this experiments subcategory listing is not exhaustive. Experiments within the scope of the ACTS Program but not identified in this subcategory listing are certainly possible.

1. Flight System Technology Experiments

Experiments that evaluate the performance and reliability of the specific multibeam communications subsystems which are included onboard the ACTS spacecraft, such as the multiple beam antennas, the baseband processor, IF matrix switch, low noise receivers and multi-power traveling wave tube transmitters.

2. Ground Experiments

Experiments that evaluate the performance of the NASA ground station, Master Control Station, and Experimenter's Station.

3. Acquisition, Tracking, and Synchronization

Experiments that evaluate acquisition, tracking and TDMA synchronization and timing considering flight system station-keeping accuracy and antenna-pointing accuracy.

4. Enhancement of Link Availability/Rain Compensation Techniques

Experiments that evaluate 30/20 GHz availability and performance improvements achievable with such techniques as earth stations with spatial diversity, adaptive power control and forward error correction.

5. Transmission Impairments

Experiments that evaluate system impairments, particularly interference, that arise as a function of beam separation.

6. Propagation Experiments

Experiments that develop propagation statistics to characterize propagation impairments such as fading, rain attenuation, scattering scintillation and depolarization for all CONUS rain zones. Experiments that evaluate quantitatively the impact of such propagation impairments on the ACTS system performance.

7. System Network Control

Experiments that evaluate the performance and efficiency of a TDMA Demand Assigned Multiple Access (DAMA) System, and that evaluate network access and control as a function of signal quality and time. Experiments that evaluate the performance of various communications protocols.

8. Low Burst Rate Earth Stations

Experiments that evaluate reliability, availability and performance of low cost, low burst rate earth stations.

3.3 Proposed Experiments

As a result of NASA's published Notice of Intent dated March 1983 [10], U.S. government agencies, industry, academia and foreign organizations have indicated interest in performing experiments that utilize the ACTS Program. These experiments have been described in various levels of detail ranging from an expression of interest in performing an experiment in a general area to the definition of a specific experiment. In many cases interest has been expressed with experiment definition contemplated during the ACTS development phase. A summary of the Notice of Intent responses is presented in Table 3.1.

The proposed experiments, when defined, may be categorized in terms of whether or not the results may lead to patents. For example, it is unlikely that an RDLP would (or could) be formed to pursue propagation experiments that are unlikely to result in a patent, product or service unless performed as one component of a larger R&D activity. On the other hand it is more likely that an RDLP would (or could) be formed to pursue experiments that are more product oriented and that are likely to result in a patentable position.

When should an RDLP be considered as a financing vehicle for ACTS experiments? The RDLP financing vehicle should be considered when the following situations exist. These situations are required in order to make it attractive from both a sponsoring organization's perspective and the investors' perspective.

- Technology Base - The RDLP should have an adequate technology base upon which it can build. This technology base may be provided by

TABLE 3.1 NOTICE OF INTENT RESPONSES [11]

ORGANIZATION	EXPERIMENT	COMMENTS
<u>COMSAT</u>	<ol style="list-style-type: none"> 1. Propagation measurements at MCS & COMSAT Laboratories. 2. Business Service Experiment 3. Demand Assignment Experiment 	Include measurement and analysis of propagation properties and statistics, evaluation of voice, data and video business services and the evaluation of the operation and dynamic response of the BBP under various traffic conditions.
<u>RCA - ASTRO</u>	<ol style="list-style-type: none"> 1. Operational evaluation of HBK and LBR. 2. Measure RF transmission parameters. 	Collection of performance data over a period of time under a variety of propagation and simulated traffic loading conditions.
<u>MOTOROLA</u>	BBP/LBR performance evaluation o Flight System Tech. Experiment o Ground Station Experiment o Enhancement of link availability and rain compensation techniques	Motorola will form an experimenter team to provide a total G/T.
<u>TRW</u>	<ol style="list-style-type: none"> 1. Open-loop CPS terminal synchronization. 2. Minimum preamble TDMA receiver. 	Development and demonstration of extremely low-cost ground terminal technology.
<u>GTE</u>	Statistical study of satellite link propagation in Ka-Band.	Propagation measurements in state of Washington.
<u>SCIENTIFIC-ATLANTA</u>	Earth station tracking performance.	Investigate and evaluate the operational aspects of an earth referenced tracking system under normal environmental conditions.
<u>ANDREW</u>	Antenna and ground terminal technology.	General interest.
<u>M/A COM</u>	Small earth terminal technology.	Small earth terminal technology for low data rate message, facsimile, paging and voice; easily transportable or mobile terminals.
<u>JPL</u>	Propagation Experiments	JPL would coordinate all propagation experiments as well as conduct propagation experiments. Investigate 30 GHz beacon for deep space network technology.
<u>NASA AMES</u>	<ol style="list-style-type: none"> 1. NAS ACTS Integrated Wideband Communications Network Experiment. 2. An experimental investigation of advanced videoconferencing systems. 	Development of remote access to a large scale computational facility; multi-location conferencing.
<u>NASA LEWIS</u>	17 experiments	Spacecraft technology, ground terminal technology, user services and video teleconferencing.
<u>ATIA-ITS</u>	Measurements of absolute delay.	
<u>U.O.T</u>	National Highway Traffic Safety Administration Crash-Test Tele-Control Satellite Experiment	Video teleconferencing
<u>COMTECH NW</u>	Ground terminal technology hardware components.	Interested in receive only ground terminal hardware operating at 20 GHz.

TABLE 3.1 NOTICE OF INTENT RESPONSES [11] (Continued)

ORGANIZATION	EXPERIMENT	COMMENTS
<u>ORI INC.</u>	1. Testing, evaluation and optimization of adaptive power control. 2. Rain Scatter Interference Experiment	Development of new or enhancement of existing algorithms for uplink & downlink power control. Collection of empirical data to support development of predictive interference models.
<u>E-SYSTEMS</u>	Electronic mail.	Interested in electronic transmission of messages or electronic mail.
<u>LNR COMMUNICATIONS</u>	Ground terminal technology hardware components.	30 GHz solid state power amplifiers, 30 GHz low noise receivers and up/down converters-frequency synthesizers.
<u>SBS</u>	Advanced Technology	General interest in both ground terminal and spacecraft technology.
<u>GSA</u>	Federal Telecommunications Services	Proposes three options from providing and evaluating federal communications service at 30/20 GHz.
<u>VPI & SU</u>	1. Multiple-Frequency Dual-Polarization Site Diversity Propagation Experiment 2. A bit error rate and dynamic depolarization compensation measurement. 3. A Position Location System Experiment using ACTS scanned beams.	
<u>OHIO STATE UNIVERSITY</u>	1. Alleviation of communications impairments due to precipitation & interference at 30/20 GHz. 2. Site diversity implementations and evaluation for 30/20 GHz satellite communications.	Incorporate HBR/LBR ground terminal, diversity site-LBR.
<u>APPLIED PHYSIC LAB (JOHNS HOPKINS UNIV.) & UNIV. OF TEXAS</u>	Bit error rate statistics and other propagation impairments at 20 and 30 GHz for a Virginia-Texas link via ACTS.	LBR stations to measure BER during periods of rain or heavy cloud conditions.
<u>UNIV. OF MIAMI</u>	Advanced communications technology satellite rain attenuation studies.	Four rain related attenuation studies. University has most of equipment needed.
<u>SOUTHERN ILLINOIS UNIV.</u>	Simulcasting of agriculture & communication. Seminars in English, Spanish & Japanese/Chinese languages via ACTS.	At least three G/T will be required.
<u>AZ TECHNOLOGY INC.</u>	Satellite systems development.	Interactive satellite data distribution and teleconferencing hardware and software to industry, government and education.
<u>ALTERNATE SYSTEMS LABORATORY</u>	Telecommunication and information services planning.	
<u>TENNESSEE STATE UNIVERSITY</u>	Measurement of atmospheric effects on signal propagation from the ACTS to a G/T in Nashville, Tennessee.	Measurements of atmospheric effects such as absorption, depolarization, scattering and scintillation.
<u>SCIENCE APPLICATIONS INC.</u>	Propagation statistics for rain attenuation for multiple ground stations using the ACTS.	Collect data to assess the limitations of current rain attenuation models.
<u>PARTNERSHIP FOR PRODUCTIVITY</u>	Communications for development.	Development and demonstration of simple, low cost satellite transceivers.

TABLE 3.1 NOTICE OF INTENT RESPONSES [11] (Continued)

ORGANIZATION	EXPERIMENT	COMMENTS
<u>NATIONAL BUREAU OF STANDARDS</u>	Orbiting standards package: Proof-of-Concept and Measurement Applications Experiment	OSP is a self-calibrating satellite module capable of emitting a beacon signal of accurately known characteristics. OSP will act as a recalibratable remote terminal of a well instrumented far-field antenna range.
<u>BRAZIL</u>	<ol style="list-style-type: none"> 1. Advanced satellite communications system. 2. Satellite communication with low cost stations using spread spectrum techniques. 3. Propagation measurements in a tropical atmosphere. 	
<u>LOCKHEED</u>	Environment monitoring experiment for ACTS.	Plasma analyzer, spectrometer unknown for energetic electrons and protons, tri-axis magnetometer, charge environment monitor.

either the limited partners or the sponsoring organization. The RDLF should have clear rights (through formal agreements) to the use of the technology base.

- Likely Proprietary Position from R&D - The contemplated R&D or experimental program should lead to a patent or other proprietary position. This is important in order to ensure a good market share which will reduce the risk associated with future payouts (i.e., royalty or other payments) desired by the limited partners. The future payouts or value provides the rate of return necessary to attract the limited partners.
- Large Potential Market - A large enough market should exist for final goods and/or services in order to yield adequate royalty (or other) payments to the limited partners and to yield a profit for the sponsoring or other participating organizations. It should be noted that typically limited partners require a return on the order of 3 to 5 times their investment (cash-on-cash ratio of 3 to 5).

- Risk - A reasonably high level of risk associated with the R&D outcome makes the undertaking of the R&D with RDLP financing more attractive to the sponsoring organization than either debt or equity financing. Unless there are other constraints (for example, the organization already has an unusually large debt/equity ratio which implies high debt financing costs), low risk undertakings are likely to be funded directly by the sponsoring organization. In the case of a start-up situation, lower risk implies that the limited partners would expect lower returns.
- Relatively Large Funding Requirement - Because of the expense currently associated with setting up an RDLP, funding requirements should exceed about \$150,000. Also, funding requirements should be large enough so that they are visible to the sponsoring organization and may have an effect on the firm's cost of capital if debt or equity funded. In other words, it is anticipated that the likelihood of using RDLP financing will increase as the ratio of funding requirement to net worth increases.
- Low Anti-Trust Risk - The likelihood of anti-trust action to disallow the RDLP should be very low. This is most likely the case when there is a single sponsoring organization and limited partners that are not major participants in the communications satellite industry.
- Funding Requirement Predominantly for R&D - Expenditures should be considered as R&D expenses by the IRS. This implies that experiments that are candidates for RDLP financing should be structured so that the RDLP funds are utilized for activities that are recognized (by the IRS) as R&D and not as marketing, manufacturing or other expenses. Only funds used for R&D get the favorable tax treatment.

4. RDLPs APPLIED TO ACTS EXPERIMENTS

The ACTS experiments, in some cases, have been described in reasonable detail whereas in other cases there have been expressions of interest in performing experiments without detailing the experiments. In no case was information available describing the role that a successful experiment or R&D project would play in the specification, production, marketing and sales of goods and/or services. Information was therefore completely lacking with respect to business potential of resultant goods and/or services. It was thus not possible to assess the impact of RDLP financing upon specific well defined situations. In the following paragraphs a number of RDLP scenarios are outlined and their potential applications are described. It is anticipated that this will provide insight into when alternate scenarios are applicable.

First, a review of the general reasons for considering the use of RDLP financing. RDLP financing provides an off-balance sheet financing alternative to the more standard forms of debt and equity financing. The off-balance sheet financing does not normally effect other financial arrangements of a sponsoring organization since the risk is entirely borne by the RDLP limited partners. If the R&D is successful the sponsoring corporation may exercise an option that results in capital gains to the partners whereas if the R&D is not successful the option is not exercised and the limited partners' investment is lost. The limited partners, to encourage their participation in stimulating R&D, receive favorable tax treatment being able to write-off their investment as it is made and being able to treat royalty or other payments as long-term capital gains. This treatment has the effect of increasing after-tax expected return on investment so as to compensate for the assumed risk.

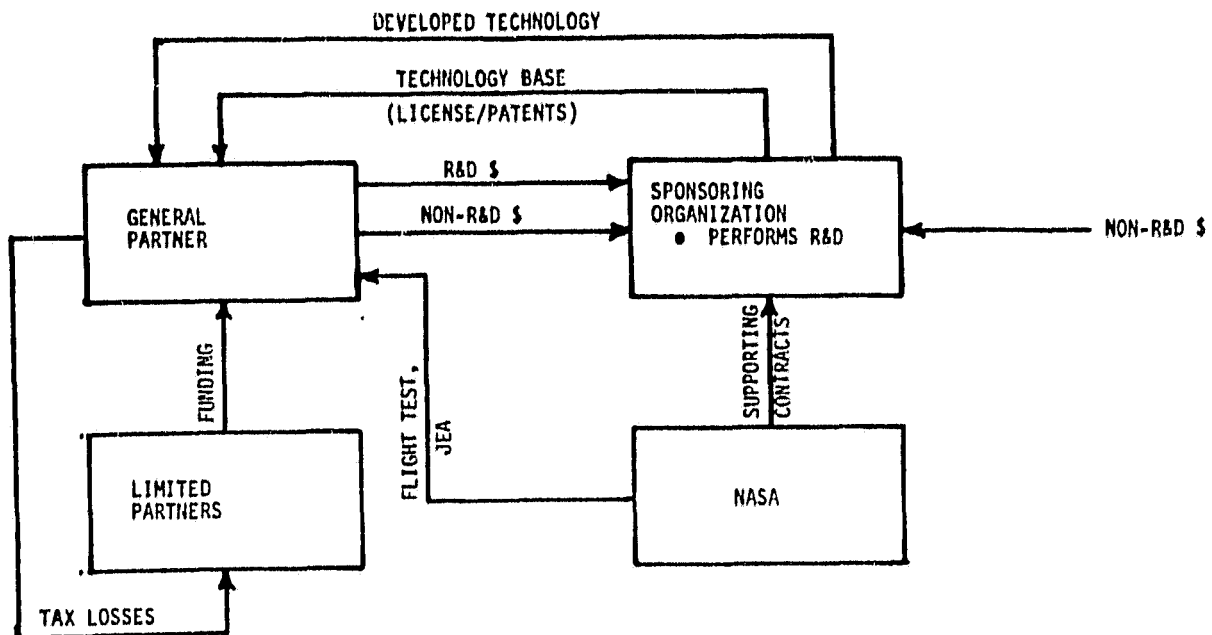
The major reasons for utilizing RDLP financing are to transfer risk, to minimize the effect of undertaking R&D on corporate cash flow and profit, and to avoid dilution that would result from increased equity financing.

In the following paragraphs four typical forms of RDLPs are described that are applicable to the financing of ACTS program experiments. These are referred to as (1) the sponsoring organization form of RDLP, (2) the sponsoring organization arrangement leading to a new venture, (3) an entrepreneur arrangement leading to a new venture, and (4) an RDLP leading to limited partners' pursuit of business alternatives.

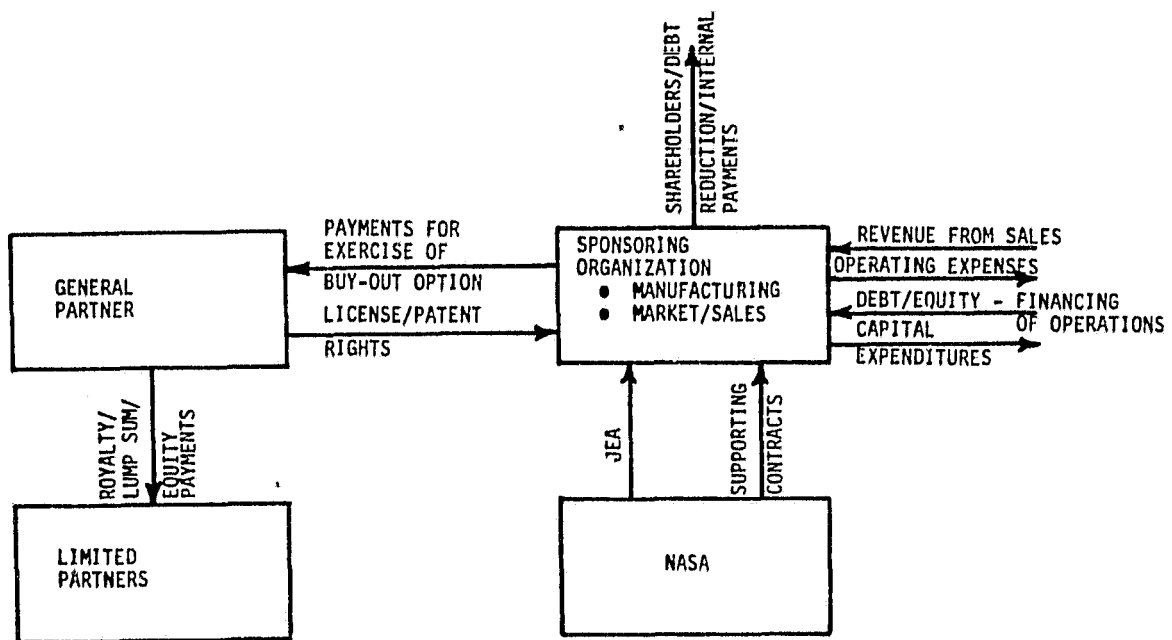
(1) The Sponsoring Organization Form of RDLP (Refer to Figure 4.1)

In the R&D phase a number of limited partners and a general partner comprise the RDLP with the limited partners providing the bulk of the funds provided by the RDLP to the sponsoring organization. A contract is entered into with the sponsoring organization whereby the RDLP acquires the technology base (through license and patent arrangements) in return for the financing and an option (exercisable at the discretion of the sponsoring corporation) for acquiring the technology resulting from the R&D project. In order to exercise the option a lump-sum buyout payment or royalty payments are made to the RDLP. NASA can provide assistance during the R&D phase by providing supporting R&D contracts, performing flight tests and entering into joint endeavor agreements. If the R&D or experiments are successful the option is exercised and the necessary payments made to the RDLP. The sponsoring organization then manufactures, markets and sells products based upon the performed R&D and experiments.

This type of structure is appropriate when the sponsoring organization is in the communications business. It is most likely that the sponsoring organization would organize such that all 30/20 GHz R&D efforts are part of the RDLP arrangement--the reason being one of separability. In other words it may be



R&D PHASE



SUBSEQUENT OR BUY-OUT PHASE

FIGURE 4.1 TYPICAL STRUCTURE FOR SPONSORING ORGANIZATION FORM OF RDLP

difficult to identify which project contributed to which product when royalties are of concern. When a straight buyout lump sum payment is made the issue of separability is of somewhat lesser importance.

Since it is currently relatively expensive to form an RDLP for funding in amounts of less than several hundred thousand dollars it is anticipated that sponsoring organizations would try to fund multiple experiments through a single RDLP financing. RDLPs are most likely to be utilized when experiment cost may become an appreciable part of annual earnings and cash flow. This is also true for the other RDLP organizational forms described in following paragraphs.

Depending upon the cost of contemplated R&D and experiments, it would seem likely that small to medium size companies would try to utilize RDLP financing. An exception to this being when a major investment is being considered to initiate a new business area by medium and large size organizations again where funding would have a major impact on annual earnings, cash flow and rates of return. As has been stated previously, RDLP financing is appropriate for the financing of R&D and experiments--it is not appropriate for funding of start-up costs, marketing expense, etc.

RDLP limited partners normally desire returns to commence in the near-term rather than in the far-term. This implies the need to have revenues (to the sponsoring organization) commence in approximately 3-4 years in order to provide royalty payments. When a lump-sum buyout is exercised, the expected time may be on the order of 3-4 years or less. Unless the experimental satellite can be used in an operational system it is unlikely that a 30/20 GHz operational system will be initiated that will provide royalties for the limited partners within 3-4 years of their providing of funds. It thus seems that lump-sum buyouts are more likely.

Propagation experiments are unlikely to form the basis of an RDLP since they in themselves will not lead to a patentable position. The greater the likelihood of patents resulting from an experiment (or group of experiments) the greater the likelihood of being able to obtain RDLP financing. This is also true for the other RDLP organizational forms described in following paragraphs.

Finally, experiments should not be capital expenditure intensive unless it is clear that the capital expenditure is a necessary part of the experiment and will have little or no value outside of the context of the R&D. If this is not the case there is a risk that the IRS will disallow that part of the RDLP financing with the consequence of reduced RDLP earnings. This is also true for the other RDLP organizational forms described in following paragraphs.

(2) The Sponsoring Organization Leading to a New Venture (Refer to Figure 4.2)

During the R&D phase this organizational structure is identical to the previously discussed sponsoring organization form of RDLP with the sole exception being the mechanism of paying the limited partners. In the sponsoring organizational form leading to a new venture it is agreed that if the R&D program is successful* that a new venture will be formed to pursue the manufacture, marketing and sales of goods and/or services that are the result of the R&D. It is also agreed in advance what equity positions the sponsoring organization and the partners will have. During the subsequent or new venture phase a separate organization is established to capitalize upon the results of the R&D. The sponsoring organization and/or other funding sources will provide the necessary debt and equity financing with the limited partners receiving dividends or achieving capital gains through sale of equity.

* Success may be measured by achieving predetermined performance goals and judgments concerning the likelihood of issuance of patents.

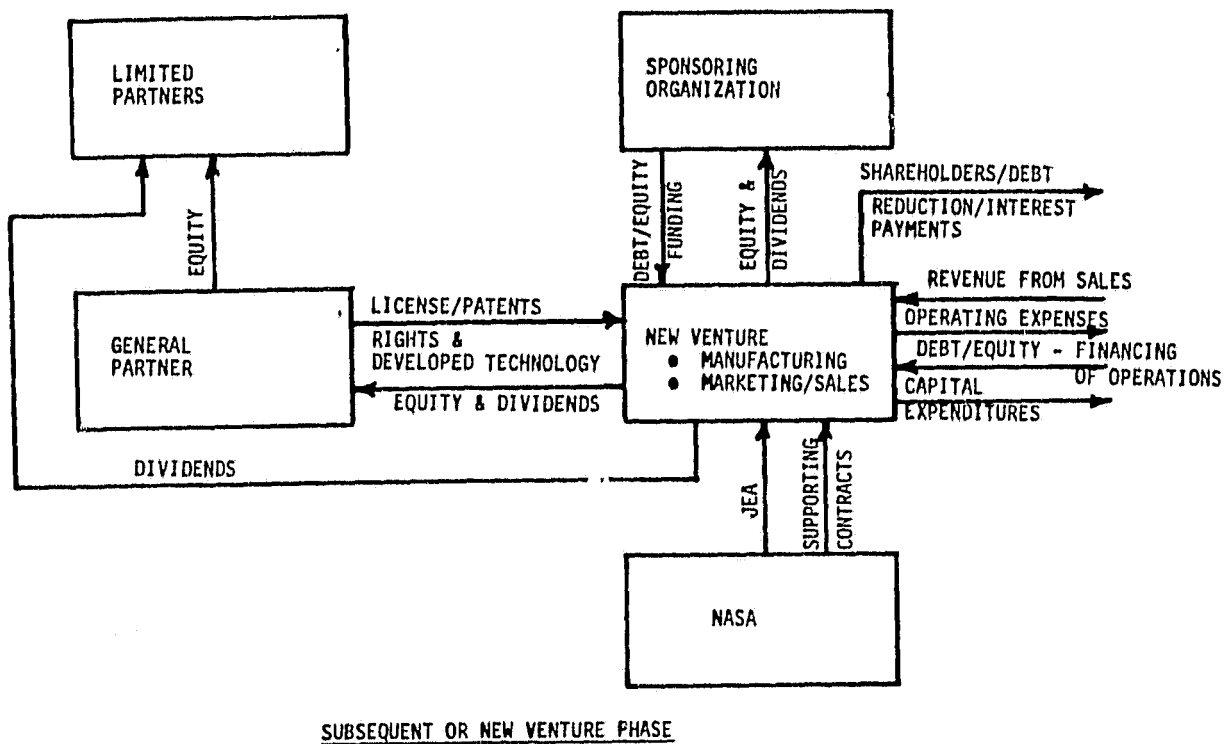
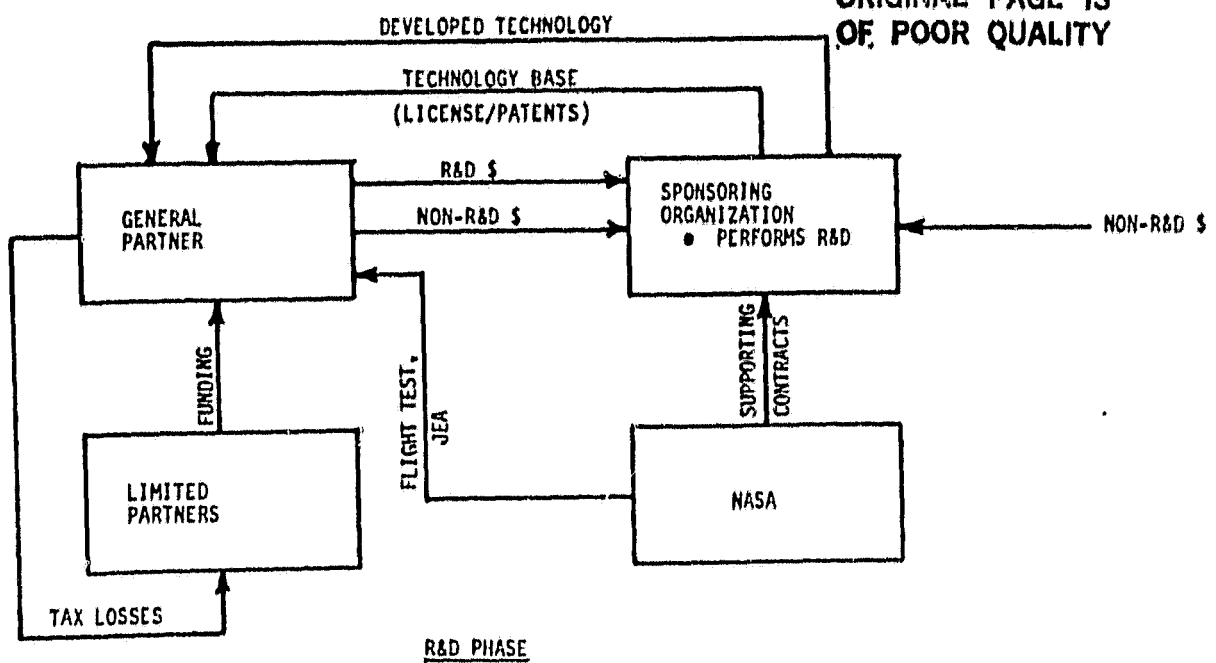


FIGURE 4.2 TYPICAL STRUCTURE FOR RDLP LEADING TO NEW VENTURE
(SPONSORING ORGANIZATION ARRANGEMENT)

As in the previous case this type of structure is appropriate when the sponsoring organization is in the communications business. It is most likely that the sponsoring organization would organize such that all 30/20 GHz R&D efforts are part of the RDLP arrangement — the reason being separability.

This type of organizational structure is established when there is a desire to have the limited partners participate in lieu of a cash payout. To avoid dilution of shareholders in the sponsoring organization, a new venture is formed and isolates the limited partners equity to the specific area of their contribution. The limited partners will prefer this type of situation rather than a lump-sum buyout when it is likely that capital gains from liquidation of equity positions will exceed the cash buyout. Again, since the partners are usually more interested in the near-term rather than the far-term these capital gains should be realizable in the 3-5 year time frame (from their initial investment).

Timing is again important. Increases in stock prices usually occur in anticipation of earnings which will occur within the next 1-2 years, not 3-5 years. Therefore, unless the experimental satellite can be used in an operational system it is unlikely that a 30/20 GHz operational system will be initiated that will provide significant revenues and earnings that will lead to the desired capital gains potential in the 3-5 year time period.

The resulting business from goods and/or services made possible from the R&D or experiments should be of sufficient magnitude to warrant setting up a new business venture. Thus, a company with sales measured in billions of dollars per year is not likely to set up a new business venture unless sales will be measured in terms of several tens of millions of dollars per year.

Another reason for the sponsoring organization desiring to set up a new venture is concerned with risk. When funding requirements for the new venture

(which may be satisfied by debt and equity financing) are of significant magnitude that excessive risk may result to the current organization if the new venture does not perform as anticipated. It is desirable to isolate the new venture and establish its own sources of funds.

(3) Collaborative R&D (RDLP) Leading to a New Venture (Refer to Figure 4.3)

In the R&D phase a number of limited partners and a general partner comprise the RDLP with the limited partners providing the bulk of the funds necessary for undertaking the R&D and experiments program. The general and limited partners organize in order to pool their experience and capabilities with the intent of jointly participating in the formation of a new venture that will manufacture, market and sell goods and/or services that are based upon the results of the R&D and experimental program. The limited partners thus contribute funds to the RDLP for performing the necessary R&D and experimentation. They also provide or contribute the necessary technology base in the form of patents, licensing and other agreements in return for agreed equity and/or royalty payments from the new venture that will be created upon successful completion of the R&D and experimental program. The general partner contracts with non-partner commercial organizations, partner commercial organizations or universities for the conduct of the necessary R&D and experimental programs. The resulting technology and patents are the property of the RDLP. During this R&D phase NASA can play a supporting role by providing supporting contracts with the organizations performing the R&D or directly with the general partner who then subcontracts the work. NASA can also provide assistance through the flight test program and enter into joint endeavor agreements.

The purpose of this organizational structure is to pool the resources of a number of organizations to perform collaborative R&D and then to participate

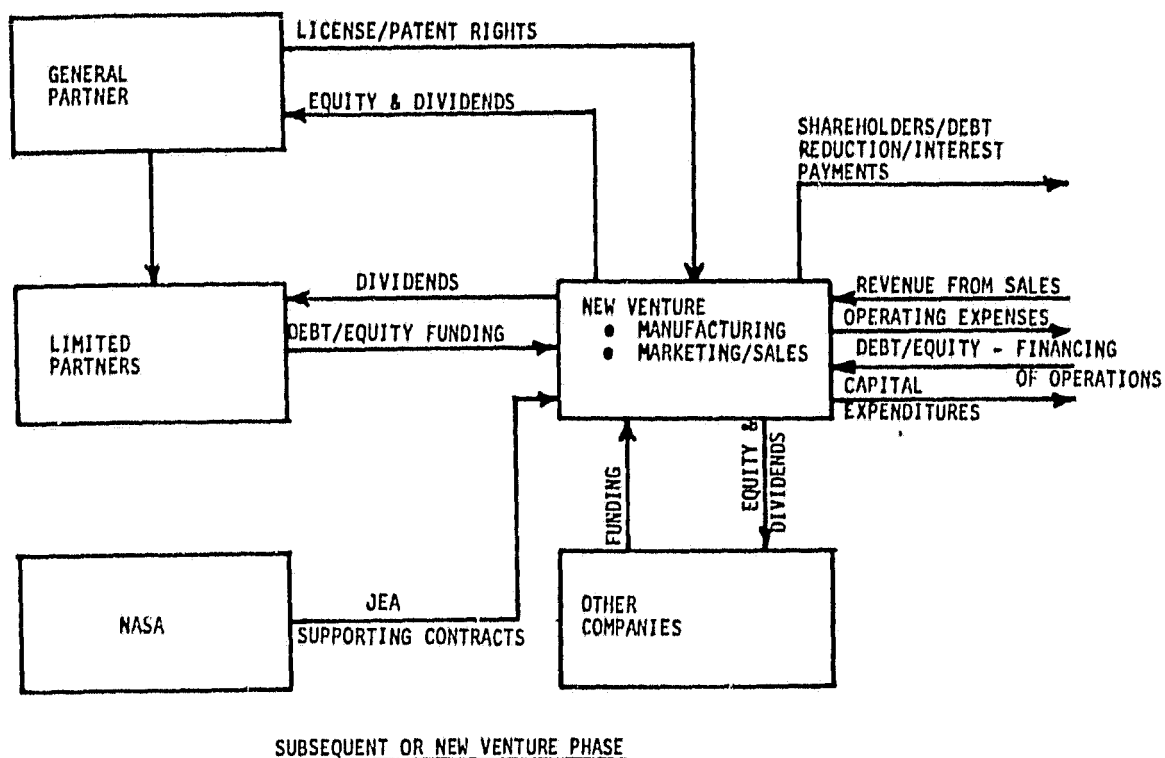
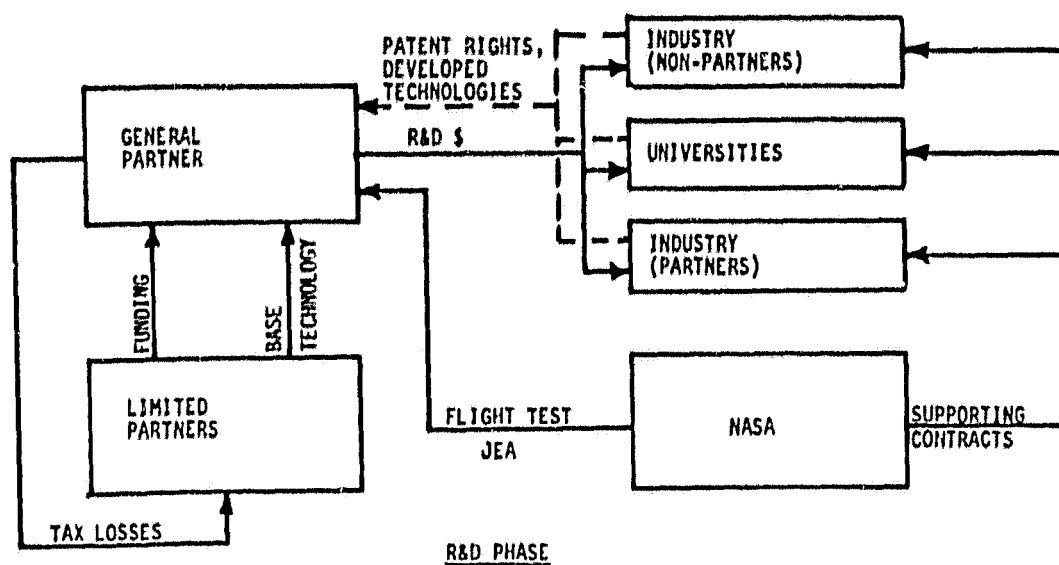


FIGURE 4.3 TYPICAL STRUCTURE FOR RDLP LEADING TO NEW VENTURE (ENTREPRENEUR ARRANGEMENT)

in a joint venture to capitalize upon the results of the R&D program. Because of this goal (i.e., a joint venture based upon a collaborative R&D and experiments program) the need for patents is not critical. The most important aspect is the desire to proceed with a cooperative joint venture.

This form of organizational structure is most likely when the contemplated business venture requires skills and capabilities well beyond those contained within a single organization. It is based upon collaborative efforts of several organizations that wish to achieve a common business objective. Since organizational (i.e., business) investors are participating rather than individual investors as the RDLP limited partners, the financial goals and objectives of the partners differ from those discussed previously. The goals and objectives are the creation of a new business venture that will contribute to the earnings of the limited partners' organizations. These goals are more in line with business venture goals rather than those of individual investors. For example, if the limited partners are interested in participating in the satellite communications area, and in particular the 30/20 GHz area, because this is their general area of business, near-term profitability and other objectives are not as critical as with individual investors who are not necessarily concerned with the business area but only with the financial returns. Thus, 3-5 or more year delays from completion of experiments to initiation of revenues is reasonable since this is expected in the satellite communications business area.

Collaborative R&D and experimental programs may be conducted by competing as well as non-competing organizations. It would seem likely that when a broad range business (for example, space systems, ground terminals and related communications services) is contemplated a collaborative R&D program leading to a joint venture may be desirable. The collaborative R&D program could encompass

programs that will lead to both patentable and non-patentable results as long as a competitive advantage is likely for the joint venture. Antitrust considerations should not be overlooked.

(4) Collaborative R&D (RDLP) (Refer to Figure 4.4)

The objective of the RDLP formed to undertake collaborative R&D and experimental programs is to develop a technology base for the collaborative partners, through a risk sharing endeavor. Upon completion of the research the individual partners are then licensed to utilize the technology results in their following business endeavors. Royalty payments may then be made according to previous agreements to the other limited partners. The R&D phase of this form of organization is the same as that of the collaborative R&D (RDLP) leading to a New Venture with the exception that licensing and royalty agreements may be entered into for the subsequent or new venture phase.

A collaborative R&D form of RDLP is likely when the performance of the R&D or experiment requires capabilities beyond that of a single organization, when there is relatively high risk and risk sharing is desired, when the cost of the R&D or experiment program is relatively high, and when the creation of business ventures requires a broad range of experiments to be performed the results of which may or may not lead to a patentable or proprietary position. For example, propagation experiments which may provide information pertinent to many future participants in the 30/20 GHz communications are likely to be prime candidates for collaborative R&D RDLPs.

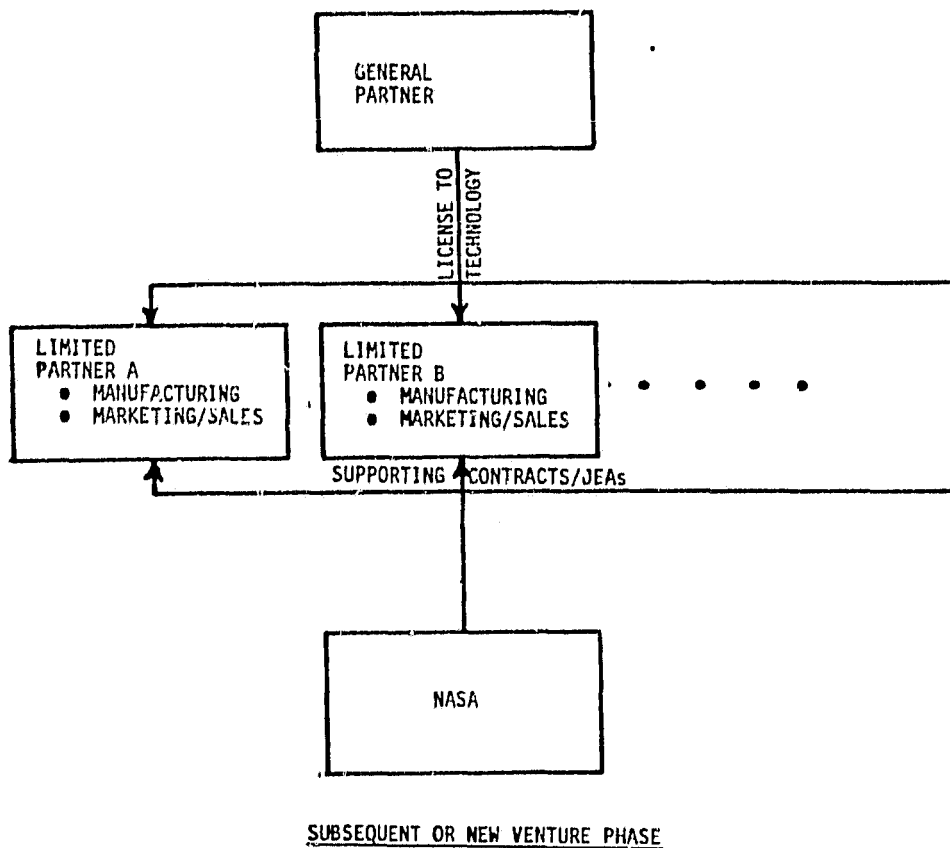
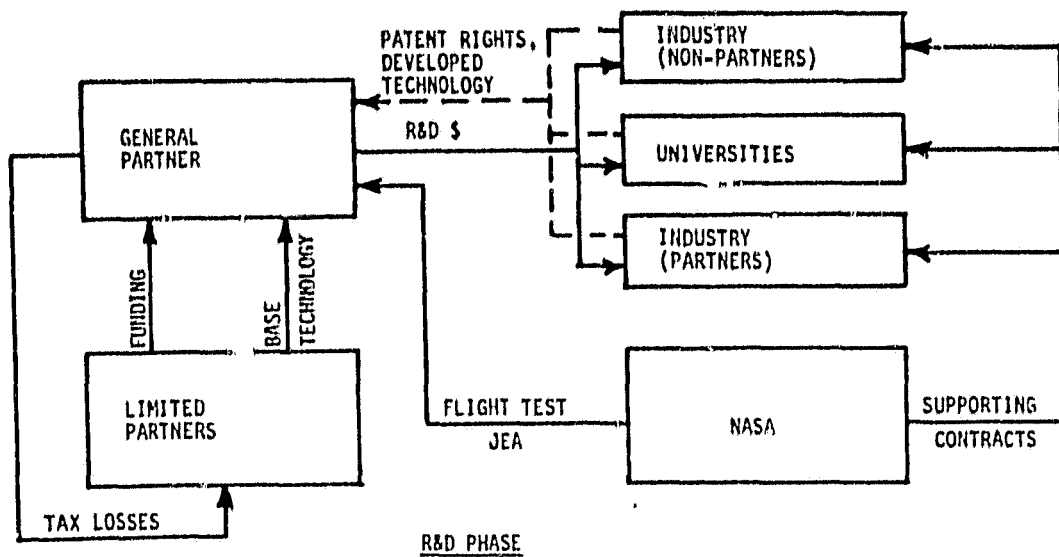


FIGURE 4.4 TYPICAL STRUCTURE FOR RDLP LEADING TO LIMITED PARTNERS PURSUIT OF BUSINESS ACTIVITIES

5. SUMMARY/CONCLUSIONS

In order to help stimulate investment in high technology R&D, the Administration has promoted the R&D Limited Partnership (RDLP). The RDLP concept enables the funding and conduct of R&D efforts in a manner that can be distinctly advantageous relative to other organizational forms and can thus have an impact on the private sector markets for NASA technology. The RDLP can provide substantial tax advantages, dramatically improving the rate of return on certain R&D activities, and it can enable collaboration between otherwise competing organizations which, outside the framework of the RDLP, would be judged to be in violation of anti-trust legislation. The RDLP allows for a basic separation between R&D and operations with each providing an expected return to offset the associated risk.

The RDLP makes it possible for companies to have another option for financing research and development. Instead of using debt provided by lenders, equity provided by stockholders, or cash generated by internal operations, a company can look to investors seeking an attractive tax shelter opportunity. An RDLP may be used to finance an existing firm's R&D, or can provide the R&D seed money for a start-up business. It offers an effective means for financing small and large scale projects.

Typically a limited partnership is formed with either an individual or a corporation as general partner; the general partner provides management and the limited partners the capital. Frequently there is a sponsoring company that provides a technology base for the partnership and performs the research for the partnership under contract. As funds are provided the limited partners may achieve tax write-offs. Upon successful completion of the R&D the sponsoring corporation may exercise an option to acquire the developed technology and

market related products in return for the partnership receiving royalty or other payments. These payments may receive capital gains treatment by the partners.

It is through the combination of high rates of return (resulting from the favorable tax treatment for the limited partners) and risk reduction (resulting from the pooling of assets) that R&D investment decisions will be effected and investments stimulated.

NASA is currently pursuing the ACTS Program. If Congress approves, a primary objective will be to make available to the public and private sectors the capabilities of an ACTS spacecraft for experimentation. A number of experiments have been proposed and general interest has been indicated for performing others. The purpose of this study was to provide insight into the role that RDLPs may play in encouraging private sector experimentation with an ACTS spacecraft with the ultimate objective of encouraging private sector use of the NASA developed communications technologies and thus increasing the rate of market development. Due to the limited state of detailed information pertaining to the proposed experiments and potential business ventures it was not possible to delineate the specific role of the RDLPs — only general concepts have been developed.

The advantages of RDLPs are

- risk transfer to limited partners
- reduced dilution and retention of control by a sponsoring organization
- improvement of cash flow by avoiding debt-service requirements
- improved financial statements due to off balance sheet financing
- tax advantages to both sponsoring organization and limited partners.

There are several disadvantages to using RDLP financing, namely

- high cost of capital (paid in the form of royalties or a lump-sum buyout) if R&D is successful

- funds restricted to financing of R&D otherwise favorable tax treatment is negated
- relatively high cost of establishing an RDLP.

The general implications of the RDLP financing on an ACTS experimental program may be summarized as follows:

- sponsoring organizations likely to be in the communications business
- multiple R&D and experimental programs are likely to be grouped together within a single RDLP
- because of the cost of creating an RDLP, R&D funding levels in excess of several hundred thousand to one million dollars are likely
- small to medium size firms are more likely to use RDLP financing than are large firms, an exception being when a major new business venture is contemplated
- because of the long time delays expected from the start of an experiment to the generation of revenue from a business venture, lump-sum buyouts are more likely than royalty arrangements
- in general, experiments that are not likely to result in a patentable or proprietary position are, in themselves, unlikely candidates for RDLP financing
- high risk experiments (that can lead to patents) are more likely to be candidates for RDLP financing than are low risk experiments
- experiments that are capital equipment intensive (where the equipment has significant value independent of the experiment) are not likely candidates for RDLP financing
- it would seem appropriate for propagation type experiments to be funded by a collaborative RDLP form.

In order to become more definitive it is necessary to perform one or more case studies. It is recommended that this be initiated such that one or more business scenarios be developed, the set of R&D projects and experiments outlined that are necessary to demonstrate feasibility of the business scenarios, and then develop and compare debt, equity and RDLP financing arrangements. This will result in more detailed information as to the specific conditions (for the ACTS

program), programs and organizational structures that may influence the rate of penetration of advanced communications services into the marketplace.

REFERENCES

- [1] Ellert, Robert B. and Michael R. Rubin, Information and Steps Necessary to Form Research and Development Limited Partnerships, Department of Commerce, 1983.
- [2] Corrigan, Richard, "Administration Pushes R&D Pooling to Maintain U.S. Lead in High Tech," National Journal, October 1, 1983.
- [3] Larson, Daniel L. and Hugh B. L. McClung, Analyzing R&D Partnerships as Financing and Investment Opportunities, R&D Funding Corporation.
- [4] Research and Development Limited Partnerships Case Studies, Office of Productivity, Technology and Innovation, January, 1984.
- [5] Moore, James A., et al., Tax and Accounting Aspects of Research and Development Limited Partnerships, Coopers & Lybrand.
- [6] Spohr, Anthony P. and Leslie Watt, Forming R&D Partnerships, an Entrepreneur's Guidebook, Deloitte Haskins and Sells, 1983.
- [7] R&D Financing and the Emerging Technology Company, Coopers & Lybrand.
- [8] Cooreel, Esq., Frederic G. et al., Research and Development Limited Partnerships - Tax Law, Securities and Accounting Aspects, October 4, 1982.
- [9] ACTS - Advanced Communications Technology Satellite Program, NASA, Office of Space Science and Applications.
- [10] Advanced Communications Technology Satellite (ACTS) - Notice of Intent for Experiments, Communications Division, Office of Space Science and Applications, NASA Hq., March 1983.
- [11] Private Communication from R.J. Schertler, ACTS Project Experiments Manager, NASA Lewis Research Center, March 5, 1984.
- [12] Moore, Nicholas G. and Frank R. Pope, The Fundamentals of Tax Sheltered Research and Development Financing, Coopers & Lybrand, August 1981.